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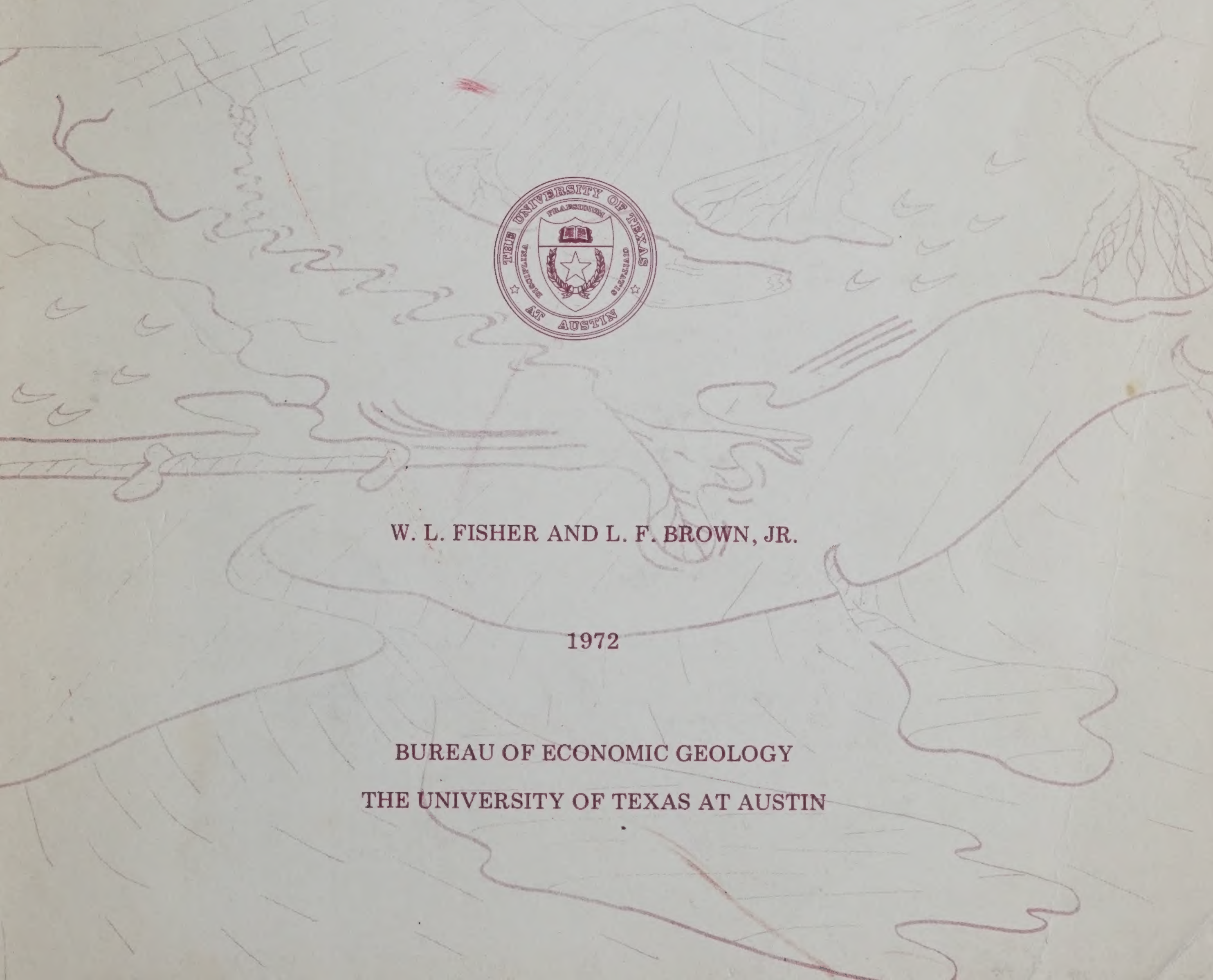
CLASTIC DEPOSITIONAL SYSTEMS - A GENETIC APPROACH TO FACIES ANALYSIS

Annotated Outline and Bibliography



W. L. FISHER AND L. F. BROWN, JR.

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BUREAU OF ECONOMIC GEOLOGY
THE UNIVERSITY OF TEXAS AT AUSTIN

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CLASTIC DEPOSITIONAL SYSTEMS--
A GENETIC APPROACH TO FACIES ANALYSES*

W. L. Fisher and L. F. Brown, Jr.
Bureau of Economic Geology
The University of Texas at Austin

INTRODUCTION

The study of clastic sediments as facies components of sedimentary basins has progressed to reasonably definitive genetic analysis in the past decade. This has been made possible by (1) the upsurge of in-depth, three-dimensional studies of modern depositional facies in relationship to sedimentary environments and associated active depositional processes, and (2) the intensive and increasing application of these models to ancient sedimentary rocks. In genetic analysis, the objective and descriptive approach is not supplanted; in fact, the application of modern depositional analogues to ancient counterparts requires thorough analysis through description, mapping, and delineation of specific rock facies. De-emphasized, however, in the genetic approach is elaborate consideration of formal nomenclature and stratigraphic codes.

The purpose of this course is to approach stratigraphy and sedimentology on a genetic basis, so that, through appreciation of sedimentary environments, depositional processes, origin of sedimentary facies, and the interrelationships of facies and depositional processes, a fuller utilization of the law of uniformitarianism to ancient sedimentary facies can be achieved.

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*Second printing, March 1975. This printing includes updated references. Following p. 211.

A modern "depositional system" is an assemblage of related facies, environments, and associated processes. An ancient depositional system is, therefore, a three-dimensional assemblage of sedimentary facies linked genetically by inferred sedimentary environments and depositional processes. This genetic linkage results from a holistic interpretation of the rocks to arrive at inferred environments and processes compatible with modern analogues. The fundamental genetic unit is the facies, defined in terms of its composition and lithology, geometry, structure trend, and other characteristics and these, in turn, related to depositional processes.

Nine principal clastic depositional systems are considered. These include:

1. Fluvial systems
2. Delta systems
3. Barrier bar-strandplain systems
4. Lagoon, bay, estuarine, and tidal flat systems
5. Continental and intracratonic shelf systems
6. Continental and intracratonic slope and basinal systems
7. Eolian systems
8. Lacustrine systems
9. Terrigenous fan (alluvial fan and fan delta) systems

Each system is considered in the following aspects: (1) Basic, operative depositional processes; (2) principal depositional environments and their interrelationships; (3) principal depositional facies and their physical and biologic characteristics; (4) ancient examples and criteria in recognition (composition, trend, sedimentary structures, internal and external geometry, and spatial facies relationships); (5) basic working models or variants within each system, combining data from both modern and ancient systems; (6) contemporaneous structural associations and system variations in differing tectonic basins; and (7) functional application of genetic stratigraphy and sedimentation (or depositional systems) to mineral exploration and basin analysis, with type examples. Certain aspects of seismic stratigraphy are outlined.

Basic understanding of sedimentary processes and stratigraphic principles (correlation, age dating, mapping, etc.) is assumed and utilized, although many standard concepts and principles are reevaluated and, in some cases, significantly modified. Special techniques are considered as tools and not as shortcuts to the understanding of clastic facies. Stratigraphy and sedimentology are not recognized as separate disciplines; studies of modern and ancient depositional facies and systems are merged. Distinctions are not made between surface and subsurface analysis, and the particular kind of information available from each is thoroughly integrated.

Emphasis obviously is placed on examples, both modern and ancient, where maximum detail is available. From these studied examples, working models are established that can, in turn, be applied to poorly known basins or to basins where stratigraphic control is limited.

The course is concluded with a comparative examination of variations in facies distribution in different types of structural basins. The interrelationship of depositional systems within different basins is emphasized, and the role of basin tectonics is outlined.

Herein are included the following: (1) a course outline, (2) a brief summary of each depositional system, and (3) an extended bibliography of each depositional system. The course is illustrated with a large number of slides.

Course Outline

INTRODUCTION

1. Depositional systems: role of genetic stratigraphy and sedimentation

2. Utility of modern and ancient depositional analogues

3. Examples of clastic systems and their relationship to basin fabric

4. Sediment dispersal systems

FLUVIAL SYSTEMS

1. Introduction: physiographic elements, river morphology, stream channel hydraulic geometry; basic flow of water in channels, cutoffs, avulsion and abandonment

2. Basic channel patterns and operating mechanisms: meandering, braided, straight

3. Flow regime, bedforms, and associated fluvial sedimentary structures

4. Principal fluvial environments and controlling processes

   Channel environments: channel floor, point bar, longitudinal bar, transverse bars, chute fronts

   Nonchannel environments: subaerial levee, crevasse splay, floodplain, flood basin, swamp, marsh, abandoned channel, swales

5. Vertical and lateral construction processes: deposition and aggradation

6. Classification of fluvial facies

7. Specific fluvial facies and sequences: characteristics and recognition (lithology, internal geometry and sedimentary structures, thickness, sequence, sand-body geometry, E-log characteristics, core interpretation, map trends, and lateral-vertical relationships)

8. Fluvial models, component facies, stratigraphy of fluvial deposits

   Fine-grained meanderbelt model
   Coarse-grained meanderbelt model
   Braided channel model
   Straight channel (distributary channel) model

9. Multistory and multilateral sand bodies: trends, geometry, variation in lateral persistence, stacking, compaction

10. Diagenesis of fluvial deposits: cementation, kaolinization, fluid migrations

11. Ancient fluvial systems: case histories (Tertiary of Gulf Coast Basin, Upper Paleozoic of U. S. Eastern Interior and southern Mid-continent, Permian of Appalachians, Triassic-Jurassic of Colorado Plateau, Cretaceous of U. S. Western Interior, Paleozoic of Donets Basin, Lower Paleozoic of central Appalachians, Devonian of Great Britain

12. Geologic history of fluvial systems: dispersal systems, tectonic implications, basin localization, association with downdip (downslope) depositional systems

13. Mineral deposits in fluvial systems: sand channels as oil and gas reservoirs, sites of uranium mineralization, association with coal and ceramic clay deposits, sand and gravel deposits, localization of ore deposits

DELTAIC SYSTEMS

1. Introduction: importance in basin fills; basic processes; definition

2. Geologic variables in delta formation (inflow and reservoir water bodies, sediment input and marine reservoir energy levels, compaction-tectonic factors)

3. Hydrodynamics of delta formation and delta building (construction and destruction)

4. Principal delta environments and facies: processes and formation, composition, preservation, internal and external geometry, facies relationship and integration

   Constructive facies: fluvial or fluvially influenced

      Framework elements: sand facies including delta front, distributary channel, subaqueous levee

      Nonframework elements: mud and organic facies including off-delta, prodelta, and ondelta plain

4. Principal delta environments and facies (continued)

   Destructive facies: predominantly marine

   Temporally distinct facies: delta margin islands, bay-sound, marsh, and shelf

   Contemporaneous facies: coastal barrier-strandplain, lagoon, tidal sands, tidal plain, and shelf

5. Basic delta types and Holocene models: setting, depositional processes, facies composition, spectral comparison, utility in ancient delta interpretation and recognition

   High-constructive lobate deltas: Mississippi Lafourche, St. Bernard, and Teche

   High-constructive elongate deltas: Mississippi Plaquemines and modern

   High-destructive wave-dominated deltas: Rhone, Po, Nile, Danube, Apalachicola, Surinam, Tabasco, Macleay

   High-destructive tide-dominated deltas: Irrawaddy, Mekong, Gulf of Papua

   Composite deltas: Niger, Fraser, Orinoco

6. Stratigraphic classification of delta systems: modern and ancient

7. Ancient delta systems: case histories

   Lower Wilcox of Gulf Coast Basin, Upper Wilcox of Texas, Yegua of Texas, Jackson of Texas, Cotton Valley of northern Gulf Coast Basin, Woodbine of northeast Texas, Vicksburg of Texas, Frio of Texas

   Upper Paleozoic of Appalachians, U. S. Eastern Interior, U. S. Midcontinent

   Cretaceous of U. S. Western Interior, Alaskan North Slope Basin

   Paleozoic of Donets Basin, USSR

   Traissic of German Basin

   Pleistocene of U. S. Gulf and Atlantic Coastal Plains

8. Delta systems and structural associations: growth faulting, salt coming, differential compaction

9. Post-depositional history of delta facies: hydrodynamics, cementation, migration of sediment hydrocarbons, conversion of sediment hydrocarbons

10. Mineral deposits in delta systems

    Oil and gas trends in Gulf Coast Basin delta systems

    Oil and gas trends in U. S. Western Interior delta systems

    Hydrocarbon formation, migration, and entrapment in relation to delta system and component facies

    Secondary porosity, permeability, cementation, and diagenesis in deltaic reservoirs

    Delta systems and coal measures

    Uranium mineralization in delta facies

STRANDPLAIN-BARRIER BAR SYSTEMS

1. Fundamentals of strike-fed systems: sediment source, transport mechanisms, relationship to dip-fed systems (fluvial and deltaic systems), basin trend and orientation

2. Distinction of strandplain and barrier-bar facies as independent systems and as constituent facies of other depositional systems

3. Principal environments and resulting facies (shoreface, beach, offshore shelf, dunes, back-barrier, tidal inlets and tidal deltas, storms and washover fans, associated lagoons, bays, mudflats, and marshes)

4. Recognition of ancient barrier-bar and strandplain sands (sequence, geometry, internal structures, facies relationship, E-log characteristics, core interpretation, map trends, orientation in respect to other depositional systems)

5. Strandplain-barrier bar models:

   Independent systems with distant strike feeding: cheniers of southwestern Louisiana and barrier islands of Texas coast

5. Strandplain-barrier bar models (continued)

   Constituent facies of high-destructive deltas: coastal barriers of Rhone, Po, Tabasco, Nile, Danube, U. S. Georgia coast

   Relict sands of high-destructive deltas (destructive phase): Outer banks of U. S. Carolina coast, coastal barriers of Dutch and German coasts

   Delta margin islands (destructive phase of high-constructive deltas): Mississippi Chandeleurs, Grande Isle, Isle Dernieres

   Strandplains associated with nonprograding river mouths: Surinam coast of South America, Mazatlan coast of western Mexico, northern coast of Sea of Azov

   Coastal barriers of predominantly tidal origin: marginal barriers of Niger delta

   Coastal barriers (destructive phase of fan deltas): Gum Hollow, Texas Coast

6. Ancient strandplain and barrier-bar systems: case histories

   Tertiary of Gulf Coast Basin: Lower Wilcox, Upper Wilcox, Jackson, Yegua, Vicksburg

   Cretaceous of Gulf Coast Basin: Paluxy, Woodbine

   Jurassic of Gulf Coast Basin: Terryville

   Cretaceous of U. S. Western Interior: Frontier, Gallup, Emory, Muddy, Pictured Cliffs, Eagle, Point Lookout, Fox Hills

   Paleozoic of central Appalachians: Chemung, Bradford, Venago

   Paleozoic of Donets Basin, USSR

   Pennsylvanian of Oklahoma: Cherokee

7. Barrier bar-strandplain systems and mineral deposits

   Oil and gas accumulations in Tertiary of Gulf Coast, Cretaceous of Gulf Coast, U. S. Western Interior, Paleozoic of central Appalachians

   Stratigraphic, nonclosure traps; seaside barrier-bar accumulations, lagoon-side strandplain accumulations; sand isolation in tidal deltas

7. Barrier bar-strandplain systems and mineral deposits (continued)

   and washover fans

   Other mineral deposits in strike-fed sand units

LAGOON, BAY, AND ESTUARINE SYSTEMS

1. Introduction: distinction of lagoons, bays, and estuaries; setting

2. Principal depositional processes; main types

3. Principal depositional environments

   Bay-lagoon environments
   Mainland-associated environments
   Barrier island-associated environments

4. Principal depositional facies (physical and biologic composition)

   Bay-margin facies
   Bay-center facies
   Tidal inlet and tidal delta facies
   Bay head-delta facies
   Washover-fan facies

5. Marine model: open bays and hypersaline or restricted bays

6. Ancient examples

7. Role in stratigraphic trapping of strike sand systems

TERRIGENOUS CONTINENTAL SHELF SYSTEMS

1. Introduction: definition; distinction of structural and depositional shelf

2. Types and distribution of shelf sediments: detrital, biogenic, and authogenic

3. Construction of continental shelves: depositional-tectonic types

   Fault block-dammed shelves: circum-Pacific shelves

3. Construction of continental shelves: depositional-tectonic types (continued)

   Organic reef-dammed shelves: eastern Gulf Coast Basin

   Diapiric-dammed shelves (salt domes and salt ridges): western Gulf Coast Basin

   Shelves at grade: shelves seaward of high-constructive delta systems

   Eroded or cut shelves: Gulf of Maine

4. Relict versus modern shelf sediments: recognition of relict sediments; sediments in equilibrium with modern shelf processes; rates of shelf deposition

5. Modern continental shelves: eastern Asiatic, Bering Sea, western U. S. shelf, Gulf of Mexico, U. S. Atlantic shelf, northeastern South America shelf, western Africa shelf, Irish Sea, North Sea

6. Shelf processes

   Depositional processes: offdeltas, storm ebbs, longshore convergence, turbidity currents, tidal currents, sand swells

   Nondepositional (destructive) processes: bioturbation (some biogenic and chemical sediments added), winnowing and reworking, bypassing

7. Shelf facies: prodelta, grade deposits, tidal sand ridges, sand swells, ebb surge deposits

8. Biogenic elements in terrigenous shelf deposits: faunal distribution, paleoecology, bioturbation, glauconites

9. Stratigraphic utility of shelf deposits

10. Shelf deposits as hydrocarbon source beds

TERRIGENOUS FAN SYSTEMS (Alluvial fans, fan deltas, and clastic wedges)

1. Introduction: distinction of fan systems from delta systems; distinction of alluvial fans, fan deltas, and clastic wedges or fan systems; occurrence; distribution; requisites for fan formation

Alluvial fans

2. Morphologic features, origin, and development
3. Processes and deposits: stream flow, debris flow, mud flows, infiltration and sieve deposits
4. Trends and facies tract: distinction of proximal and distal fan facies

Fan deltas

5. Morphologic features, origin, and development
6. Processes and deposits: channel, fan plain, fan head, distal fan, destructional phase deposits
7. Trends, facies tract, and relationship to subaqueous depositional systems

Fan systems or clastic wedges

8. Development of compound fans; occurrence, geologic distribution, and implication
9. Ancient examples: Triassic Newark, Eagle Mills, and New Red Sandstone; Paleozoic Appalachian wedges; Devonian Old Red Sandstone; Paleozoic of Ancestral Rockies; Cretaceous of Western Interior United States
10. Relationship of fan systems to other depositional systems
11. Mineral deposits in fan systems: oil and gas from destructional bars (Appalachians, south and central Rockies, southern Mid-continent)

LACUSTRINE SYSTEMS (nonglacial)

1. Significance of lacustrine systems: oil shales and unique salts, model for density underflows, delineation of Gilbert-type deltas
2. Limnological processes: thermal and chemical stratification of water bodies, seasonal turnover; terrain influence on water chemistry

3. Varving: process, variety, and implications

4. Lacustrine environments and models: closed and open lakes

5. Principal lake facies (lithology, structures, biota, mineral composition, cycles)

   Closed lake facies: thermally stratified deposits
   chemically stratified deposits

   Open lake facies

   Marginal lake facies

6. Gilbert deltas: inflow characteristics, depositional processes, development of top-, fore-, and bottom-set deposits

7. Lacustrine underflows: density currents, relationship to deep sea density currents, lacustrine turbidites

8. Modern lakes: limnology, facies, processes

   Lake Mead

   Lac Leman

   Lake Constance

   Dead Sea

   Lakes in other depositional systems: mainly fluvial and deltaic systems

9. Ancient lacustrine systems: facies tracts and sequence, composition, associated mineral deposits

   Bonneville and Great Basin Pleistocene lakes, including playas and salt flats

   Mississippian Lake Albert

   Eocene Green River lakes

   Triassic Lockatong lakes

   Jurassic Todilto evaporite lakes

   Oligocene Florissant lakes

10. Oil shales in lacustrine systems: origin, facies association, distribution; lacustrine sediments as hydrocarbon source beds

CONTINENTAL SLOPE AND ABYSSAL SYSTEMS

1. Introduction: definition and occurrence
2. Principal depositional processes: pelagites, turbidity currents, deep counter currents, slumping, fan formation
3. Physiographic features of deep ocean basins: delta cones, abyssal plains, submarine canyons, submarine fans
4. Origin and mechanics of turbidity currents
5. Origin and mechanics of contourites
6. Characteristics of submarine fans: submarine channel deposits, proximal fan, distal fan, marginal plain; structural types and variations; flysch sequences
7. Criteria for recognition of ancient deep-water deposits
8. Development of continental rise: importance in basin infilling; relationship to paralic deposition; bearing on shelf construction
9. Ancient deep-sea systems: Ventura Basin, Marathon Basin, Appalachian foredeeps
10. Basic slope models: uplap and offlap systems
11. Deep-sea deposits in oil and gas exploration

EOLIAN SYSTEMS

1. Introduction: physics of windblown sand
2. Distribution of eolian systems: climatic parameters; continental versus coastal dune fields; independent eolian systems; constituent facies in other depositional systems
3. General features of eolian sands: lithology, structures, petrology, distribution

4. Basic dune types: transverse, barchan, parabolic, dome, longitudinal, seif, reversing, star
5. Internal structures of sand dunes: types and relationship of specific sedimentary structures, comparison of structures
6. Regional trends in eolian systems: variations in dune type and eolian structures
7. Vertical and lateral trends in structures of specific dune types
8. Preservation of eolian deposits: water table bedding
9. Modern eolian systems: White Sands National Monument, northern Africa, Middle East, South Texas coastal and inland dunes, Oregon coast
10. Ancient eolian systems: Permian and Mesozoic of Colorado Plateau
11. Eolian deposits as potential oil and gas reservoirs: Rothliegende of North Sea area

BASIN ANALYSIS

1. Techniques and methodology
2. Genetic facies and depositional systems related to tectonic framework
3. Structural associations

FLUVIAL SYSTEMS -- Summary

1. Channel geometry: Controlled by discharge, caliber, and sediment load (independent factors); by slope (dependent factor); by channel width and depth, flow velocity, bed roughness (neither wholly dependent nor wholly independent)

2. Channel patterns

   a. Braided: low sinuosity; marked by successive divisions and rejoining of flow around alluvial islands
   b. Meandering: high sinuosity; more or less regular inflections in channel direction; scour pools at points of inflection, riffles between
   c. Straight: as aggrading streams best developed on delta plains as distributary channels; thalweg shifts but channel does not meander

3. Flow of water in channels

   a. Reaches: maximum velocity in center, decreases to sides; maximum turbulence toward sides of channel and channel floor
   b. Bends: channel asymmetrical, gentle on convex side, steep on concave side; in low stage, maximum velocity close to concave bank, maximum turbulence close to foot of concave bank; convex side is shoal and irregular
   c. Flow at surface and depth: excepting high stage, maximum velocity swings from concave bank across reach to opposite concave bank; during flood and increased velocity, flow less sinuous, maximum velocity swings out from concave bank to bar, may scour bar to give chute channels

4. Load types: Bedload and suspended load

5. Processes

   a. Meandering streams: shift of thalweg results in erosion on concave bank and deposition on next downstream convex bank to form point bar; with complementary cut and fill process stream meanders and shifts laterally, result is accretion topography formed by a series of point bars
      Point bars: aggradation of bed load against shoal convex bank; build up to about 80 feet depending on bank stability and, in turn, on bedload/suspended load ratio
      Formation: shift in maximum velocity to concave bank results in superelevation of water surface toward concave bank, cross-channel current is set up with velocity about 15% of downstream velocity, flows toward convex bank; bedload carried up the convex bank; as bar is ascended during flood, progressively coarser materials are dropped out, giving fining upward sequence in tex-

ture and scale
Lateral erosion rates: up to 2,500 feet per year reported; 500 feet per year in lower Mississippi River

b. Levee formation: in flood stage, channel overflows banks; resulting decrease in velocity causes deposition; coarsest sediment adjacent to channel, fines carried to floodbasin; levee and floodbasin built through vertical accretion in contrast to lateral accretion of point bars

c. Straight streams: where aggrading associated with extensive levees that lead to channel stability and confinement; channel cross section symmetrical; shift of thalweg occurs with minor point bars developed but principal deposition along channel floor

d. Braided streams: broad, shallow streams characterized by incompetence in transporting coarsest fraction; high bedload, low suspended load; during flood, load moved as a series of transverse bars; longitudinal bars built from nucleus of coarse material not moved by stream

e. Crevassing: during flood, excess water from channel leaves through isolated low section in natural levee; once initiated, breach is scoured and deepened; sediment load deposited on lower slope of levee; result is a crevasse splay

f. Cut offs: chute cut off, channel shortened by cutting new channel along a swale in meander-belt neck cut off, abandonment of meander, either by gouging new channel across narrow neck or through capture of one loop by the next upstream, resulting in oxbow lake

g. Avulsion: sudden abandonment of part or whole of meander belt by stream from some new course at lower level on floodplain; local crevassing may lead to permanent change of stream course and major shift or avulsion

6. Flow regime and bedforms

a. Lower flow regime: resistance to flow large, sediment transport small; lower part gives small-scale ripples with small-scale cross stratification; upper part of lower flow gives large-scale ripples or dunes with large-scale cross stratification; transport in discrete steps; bedform roughness predominates; water surface and stream bed out of phase

b. Transitional flow regime: characterized by washout dunes

c. Upper flow regime: resistance to flow small, sediment transport large; resulting bedforms are plane bed and antidune; internal structures marked by flat bedding, either horizontal, plane, or gently undulating, surfaces of laminae show primary current lineation; transport is continuous; grain roughness predominates; water surface and stream bed in phase

7. Fluvial environments and facies

    a. Channel floor: deeper parts of stream; coarsest sediment in system left as residual accumulation or lag; moved only during exceptional floods; fills scours in channel; resulting deposit is commonly conglomeratic, shows large- to moderate-scale trough cross beds, and forms basal unit in channel sequence
    b. Point bar: extends up from lag deposits; as thick as channel in which it was formed; in fine grained systems up to 80 feet, in coarse grained systems about 20 feet; made up predominantly of sand; has shape of individual meander belt, asymmetrical in cross section; in fine-grained point bars, sequences fine upward in texture and scale of stratification, lower part with large-scale troughs, tabular cross beds common on downstream end, upper part commonly with horizontal bedding; in coarse grained point bars, no vertical trend in texture or structures, main structures large- to moderate-scale troughs, few tabulars, and commonly large-scale foreset cross stratification developed as chute-front deposits; lateral shift of meander belt gives sand unit of varying width, up to 30 miles; fine-grained meander belts commonly multistoried and with complete point-bar sequences; coarse-grained meander belts commonly multilateral with incomplete point-bar sequences
    c. Channel bar: bars formed within channel, common to braided streams; common types are transverse bars and longitudinal bars; marked by few stratification types, generally plane bedded flanked by small tabulars or foresets and minor small-scale troughs; lateral discontinuity of sedimentation units; resulting deposit a highly irregular multilateral sand
    d. Swale (fill): chiefly fine grained sediments filling arcuate depressions between point-bar ridges in meander belt; overbank deposition; generally 10 to 15 feet thick, 30 to 100 feet wide, depending on relief of point-bar topography; fill mostly mud, laminated, suspension deposition
    e. Chute cut off: formed by scouring swale during flood, swale tends to straighten; bedload may be transported through cut off and be deposited as large-scale foresets at downstream end; abandoned chute fill similar to swale fill
    f. Levee: sinuous, ribbon-like, prismatic body of sediment, triangular in cross section; size depends on size of river and amount of suspended load; best developed on concave bank and slightly upstream of point bars in fine-grained meander belts; flanks both sides of aggrading straight stream; coarsest sediments adjacent to channel, fine away from channel; rapid interbedding of coarse and fine sediments; primary structures small-scale troughs, wavy laminations; primary structures generally destroyed; root mottling

common; commonly oxidized with concretions abundant

g. Crevasse (crevasse splay): narrow to broad localized tongues of sediments, sinuous to lobate in plan, deposits over lower slopes of levees and outer margins of floodbasins; range in thickness from few inches to several feet; as coarse as or commonly coarser than associated levee deposits

h. Floodbasin and floodplain: accumulation of fines suspended in floodwaters in low areas marginal to channels and levees; finest sediment in fluvial system; primary structures mostly uniform lamination; shrinkage cracks common; root mottling; homogenized soil zones; swamps may be common, giving local organic deposits

i. Abandoned channel (channel fill): fill of channels that have been abandoned or reduced in slope and depth due to reduced sediment supply; common occurrence is in fine-grained meander belts where cut off takes place; shape is that of channel at time of abandonment, thicker sequence of fill adjacent to concave bank; marked by sand plug adjacent to active channel, remainder of channel filled with fines; laminated muds, may be burrowed; organics common

8. Fluvial models: The four basic fluvial models outlined below represent endpoints in a spectrum of fluvial systems; they have been synthesized from salient features of both modern and ancient case studies

a. Braided stream model

1. Setting: best developed as upstream very high bedload fluvial facies where slope is relatively high (though here not well preserved except as parts of alluvial fans); and deposited under low flash-discharge conditions; local downstream facies where stream traverses noncohesive fill or along zone of tectonic or physiographic-induced slope increase (these local facies more likely to be preserved); prominent constituent facies in alluvial-fan systems

2. Geometry of channel units: essentially flatbedded, discontinuous, lenticular, tabular; longitudinal bars commonly about 40 feet wide, 400 feet long, tapered; units normally less than 2 feet thick; axis of longitudinal bar parallel to flow, transverse bar normal to flow

3. Structures: predominantly parallel bedding and tabular cross beds; minor trough cross beds and ripple cross laminations; structures of moderate scale, normally less than 2 feet; troughs commonly associated with debris piles and longitudinal bars; parallel beds flanked downstream and laterally by tabular cross beds, ripple cross lamination below tabulars (if sediment no

larger than medium sand); small troughs in upper part of bar. Transverse bars: chiefly tabular or planar cross beds, commonly of finer texture than longitudinal bars

4. Composition and textures: commonly but not invariably coarse grained, very few fines or topstratum deposits accumulated or preserved; poorly to moderately sorted; longitudinal bar deposits fine and become better sorted distally
5. Degree of channel scour: slight, individual channels delineated only by textural differences or discontinuities in structural trend; scour chiefly marginal to longitudinal bar when it becomes emergent
6. Distribution of sand facies: form multilateral sand facies; width/thickness of facies and individual sand units high
7. Current pattern and directional features: low-sinuosity streams, anastamosing; entire facies elongate in direction of flow; variance in specific directional features will depend on relative abundance of structural types (may be very high, up to 90°)
8. Depositional units: longitudinal and transverse bars
9. Associated fluvial facies: poorly developed topstratum muds except as local channel fill; no levee deposits; no *in situ* organics preserved though longitudinal bars commonly vegetated; sand to mud ratio of system high
10. Main distinguishing features: few stratification types, lateral discontinuity of individual sedimentation units; may be dominated by either parallel laminae or beds or tabular cross beds (as number of tabular cross beds increases, trough cross beds increase); few ripples; high sand facies, multilateral

b. Stabilized straight (distributary) channel model

1. Setting: delta plain of high-constructive delta systems; built by high, continuous-discharge streams with balance of mud and sand for levee construction and facility for differential compaction; very low gradient streams, aggrading
2. Geometry of channel units: elongate symmetrical channel sands, convex downward base, flat top; up to 300 feet thick and about 4 to 5 miles wide; thickness commonly due to superposition of multiple channel sands
3. Structures: chiefly troughs with climbing ripples toward channel margins, few tabulars; original structures commonly obliterated by compactional distortion
4. Sequence of structures: (base to top) (1) massive to highly distorted with moderate to small-scale injections and convolutions; (2) troughs of moderate to large scale; (3) troughs with a few tabular cross beds preserved; (4) climbing ripple cosets,

migration away from thalweg, transitional with levees; (5) laminated channel-fill muds abruptly overlying entire sand body (fill muds commonly burrowed). No measurable trend in scale of structures; abandoned channel-fill muds commonly scoured by reactivated distributary channel

5. Composition and textures: fine to medium grained sand, poorly to moderately well sorted, mud clasts and wood fragments common; coarsest grained sediment confined to channel. No definable upward fining in texture, characterized by vertical uniformity
6. Degree of channel scour: generally slight; principal accumulation by downward accretion through subsidence and differential compaction in high mud framework; basal contact marked by distortion rather than by extensive scour
7. Distribution of sand facies: width/thickness ratio of sand body low; multistorying common due to differential compaction and subsidence and tendency for distributaries to reoccupy abandoned distributaries
8. Levees: very well developed, but rarely overlying channel sand body or channel fill; commonly root mottled and concretionary
9. Current pattern and directional features: very low sinuosity streams; unidirectional with relatively low variance
10. Depositional units: bedload deposition, chiefly on drop of flood stage; channel confined and embanked without significant lateral migration; insignificant development of point bars
11. Associated facies: well developed levee deposits, crevasse deposits, and interdistributary muds with abundant in situ organics. Sand/mud ratio of delta-plain facies low
12. Isolith pattern and regional trend: parallel or angular to depositional slope; distributive
13. Main distinguishing features: symmetrical channel sands enclosed by muds with abundant bedded organics and minor sands; distributive pattern; uniformity in vertical sequence; flanking position of levee deposits; multistorying common; individual channel units thick; basal contortion; unidirectional trends

c. Fine-grained meander belt model

1. Setting: low gradient, moderately high discharge, mixed load streams on aggrading alluvial plains; (under relatively uniform discharge sand) deltas
2. Geometry of channel units: commonly multistoried; asymmetric channel belts, convex downward (base and cut-bank side of channel erosively bounded), upper part transitional;

average thickness of individual meander-belt sand unit 40 to 80 feet, if thicker involves channel superposition; width 5 to 10 miles, commonly less

3. Structures: sands - predominantly moderate- to large-scale troughs, few tabular cross beds with small-scale troughs, some horizontal beds, abundance and variety of ripple forms; levee deposits (sands and silts) extensively root mottled and concretionary; overbank muds laminated to mottled; delicate ripple cross laminae, shallow scour and fill, some crayfish burrows, root mottles
4. Sequence of structures: (base to top) (1) moderate- to large-scale troughs with basal channel lag; (2) tabular cross beds with minor small-scale troughs; (3) horizontal or parallel beds with parting lineation; (4) current ripples. Overlain by laminated muds (clay plug) of swale fill and/or mottled and concretionary levee deposits. Overbank muds laminated to mottled. Complete point-bar sequence commonly developed; upward fining in scale of sedimentary structures
5. Composition and textures: chiefly fine grained sand, ranging from gravel at base to muds at top. High clay-pellet sand and plant debris in upper point bar. Upward fining of textures
6. Degree of channel scour: prominent along cut-bank or steep side of channel unit or meander-belt unit due to lateral cutting; well developed basal scour
7. Distribution of channel and meander-belt units: width/thickness ratio of sand body moderate; multistorying common
8. Levees: moderately well developed especially above and lateral to steep lateral margin of meander-belt sand facies; veneers and overlies channel sands
9. Current pattern and directional features: moderate to very high sinuosity streams; average vector parallel to sand-body trend but with a high variance
10. Depositional units: lateral erosion and accretion in a meandering stream with point bars accreted on sedimentation side during flood stage
11. Associated fluvial facies: well developed topstratum or overbank muds enclose meander-belt sand body, levee deposits and channel-fill muds; levee deposits overlie channel sand; channel fill best developed on cut-bank side of channel unit and commonly with abundant woody organics; coals parallel trend of sand body. Sand to mud ratio moderate to low
12. Isolith pattern and regional trend: sand bodies roughly parallel to depositional slope, commonly tributary, may be distributary
13. Main distinguishing features: fine grained sand associated with abundant muds and some organics; complete point-bar

sequence with troughs dominant; levees overlie channel sand; multistorying of meander-belt sand common; individual channel units moderately thick

d. Coarse-grained meander belt model

1. Setting: lower parts of moderate to high bed-load fluvial systems under conditions of locally higher gradient (tectonic or physiographic control) or over high sand terraces under lower to moderate discharge; would probably braid if not stabilized by vegetation
2. Geometry of channel units: multilateral sand body built of a complex of partly preserved channel and meander-belt units; individual meander-belt units 10 to 25 feet thick and up to 5 miles wide; erosively bounded; mappable sand units built up of superposed and adjacent meander-belt sand bodies up to 200 feet thick and 30 miles wide
3. Structures: chiefly moderate- to large-scale troughs and wedge sets; few tabular cross beds with small troughs; very few horizontal or parallel inclined beds; ripples confined to chutes and toes of wedge sets
4. Sequence of structures: (base to top) (1) large troughs (channel lag); (2) moderate troughs and tabulars with minor small troughs; (3) wedge sets or avalanche beds; (4) parallel inclined laminae with minor scour and fill and thin tabulars. No upward fining in scale of structures; in fact, avalanche structures commonly largest scale
5. Composition and textures: fine to chiefly coarse grained sand, granule to fine pebble gravel common; very little mud or topstratum. No upward fining in textures; coarsest grain associated with wedge sets and lower parts of tabulars
6. Degree of channel scour: moderate
7. Distribution of sand facies: width/thickness ratio of sand body very high; multilateral
8. Current pattern and directional features: moderate sinuosity streams; relatively low directional variance, lower than fine-grained meander-belt and braided facies
9. Depositional units: troughs fill in channel and adjacent convex bank by advancing sand dunes; tabulars formed by sand waves advancing on relatively smooth surface; wedge sets formed as chute-front deposits (foreset beds) of numerous chute cutoffs; bankfull conditions involve entire valley width with upper flow regime near tree line developing parallel laminated coarse grained units with minor trough fill and tabulars; complex accretes laterally

10. Associated fluvial facies: poorly developed or preserved topstratum deposits with most fines carried through the facies; principal topstratum deposits represented by mud filled with sand or not preserved; very poorly developed levees, stabilized by vegetation
11. Isolith pattern and regional trend: individual channel units parallel to depositional slope; resultant multilateral sand body normal to slope
12. Main distinguishing features: moderately coarse-grained sand facies with little mud; incomplete point-bar sequence (lower part only); abundant (up to 1/3) wedge-set cross beds; multilateral sand body; may include some braided-stream structures

9. Mineral reservoirs: Fluvial sand facies provide potentially good reservoirs for oil and gas from the standpoint of primary permeability and porosity; structural traps commonly owing to differential compaction, especially in high-mud systems, and stratigraphic traps arising from irregular depositional topography are, in some cases, significant. Commonly, a principal limitation is the distance of fluvial channel sands from potential marine source beds. Many so-called channel-sand reservoirs are, in reality, elongate delta sand bodies. Other important mineral accumulations are a variety of placer deposits, especially base metals. Special ceramic clays such as kaolinites are common adjuncts. Fluvial coals commonly flank high-mud fluvial channel deposits. Uranium roll-front deposits are commonly hosted in channel-sand facies.

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Selected References

Ackers, P. (1964) Experiments on small streams in alluvium: Proc. Amer. Soc. Civil Engrs., Hydraulics Div. Jour., vol. 90, pp. 1-37.

Adler, A.A., and Lattman, L.H. (1961) Floodplain sediments of Halfmoon Creek, Pennsylvania: Pennsylvania State Univ., Min. Ind. Expt. Sta. Bull., vol. 77, pp. 1-11.

Allen, J.R.L. (1962a) Lower Old Red Sandstone of the southern British Isles: a facies resembling the Alpine Molasse: Nature, vol. 193, pp. 1148-1150.

-------(1962b) Intraformational conglomerates and scoured surfaces in the Lower Old Red Sandstone of the Anglo-Welsh Cuvette: Liverpool-Manchester Geol. Jour., vol. 3, pp. 1-20.

-------(1962c) Petrology, origin, and deposition of the highest Lower Old Red Sandstone of Shropshire, England: Jour. Sed. Petrology, vol. 32, pp. 657-697.

-------(1963a) The classification of cross-stratified units with notes on their origin: Sedimentology, vol. 2, pp. 93-114.

-------(1963b) Asymmetrical ripple marks and the origin of water laid co-sets of cross strata: Liverpool-Manchester Geol. Jour., vol. 3, pp. 187-236.

-------(1963c) Henry Clifton Sorby and the sedimentary structure of sands and sandstones in relation to flow conditions: Geol. en Mijnbouw, vol. 42, pp. 223-228.

-------(1964) Studies in fluviatile sedimentation: six cyclothems from the Lower Old Red Sandstone, Anglo-Welsh Basin: Sedimentology, vol. 3, pp. 163-198.

-------(1965a) Fining-upwards cycles in alluvial successions: Liverpool-Manchester Geol. Jour., vol. 4, pp. 229-246.

-------(1965b) The sedimentation and paleogeography of the Old Red Sandstone of Anglesey, North Wales: Yorkshire Geol. Soc. Proc., vol. 35, pp. 139-187.

-------(1965c) A review of the origin and characteristics of Recent alluvial sediments: Sedimentology, vol. 5 (special issue), pp. 91-191.

Allen, J. R. L. (1965d) Upper Old Red Sandstone (Farlovian) paleogeography in south Wales and the Welsh borderland: Jour. Sed. Petrology, vol. 35, pp. 167-195.

-------(1966) On bed forms and paleocurrents: Sedimentology, vol. 6, pp. 153-190.

-------(1968) On the character and classification of bed forms: Geol. en Mijnbouw, vol. 47, pp. 173-185.

-------(1970) Studies in fluviatile sedimentation: a comparison of fining-upward cyclothems, with special reference to coarse-member composition and interpretation: Jour. Sed. Petrology, vol. 40, pp. 298-323.

-------, and Friend, P. F. (1968) Deposition of the Catskill facies, Appalachian region, with notes on some other Old Red Sandstone basins: Geol. Soc. Amer. Spec. Paper 106, pp. 21-74.

Anderson, A. G. (1942) Distribution of suspended sediment in a natural stream: Amer. Geophys. Union Trans., vol. 23, pp. 678-683.

-------(1953) The characteristics of sediment waves formed by flow in open channels: Proc. 3rd Midwestern Conf. Fluid Mech., pp. 379-395, Minneapolis, Minn.

Anderson, M. J. (1961) Geology and petrology of the Trivoli Sandstone in the Illinois Basin: Illinois Geol. Survey Circ. 316, 31 pp.

Arnborg, L. (1957) Erosion forms and processes on the bottom of the River Angermanalven: Geograph. Ann., vol. 39, pp. 32-47.

-------(1958) The lower part of the River Angermanalven: Univ. Uppsala, Geograph. Inst. Pub., vol. 1, pp. 181-247.

Badea, L. (1967) Morphological transformations in the Danube River channel between Turnu-Severin and Turnu-Magurele: Natura. Seria Geografie-geologie, vol. 19, pp. 45-51 (Rumanian).

Bagnold, R. A. (1960) Some aspects of the shape of river meanders: U. S. Geol. Survey Prof. Paper 282-E, pp. 135-144.

Baker, D. R. (1962) The Newcastle Formation in Weston County, Wyoming; a non-marine (alluvial plain) deposit: Wyoming Geol. Assoc. 17th Field Conf. Guidebook, pp. 148-162.

Ball, H. W., et al. (1961) The Old Red Sandstone of Brown Clee Hill and adjacent area: Brit. Museum Geol. Bull., vol. 5, pp. 178-310.

Beerbower, J. R. (1961) Origin of cyclothems of the Dunkard Group (Upper Pennsylvanian-Lower Permian) in Pennsylvania, West Virginia, and Ohio: Bull. Geol. Soc. Amer., vol. 72, pp. 1029-1050.

-------(1964) Cyclothems and cyclic depositional mechanisms in alluvial plain sedimentation, in Symposium on cyclic sedimentation: Kansas Geol. Survey Bull. 169, pp. 31-42.

Belt, E. S. (1968) Carboniferous continental sedimentation, Atlantic Provinces, Canada: Geol. Soc. Amer. Spec. Paper 106, pp. 127-176.

Bernard, H. A., et al. (1962) Recent and Pleistocene geology of southeast Texas, in Geology of Gulf Coast and guidebook of excursion: Houston Geol. Soc., pp. 175-224.

-------, and LeBlanc, R. J. (1965) Resume of the Quaternary geology of the northwestern Gulf of Mexico Province, in The Quaternary of the United States: VII INQUA Congress, pp. 137-185.

-------, and Major, C. F., Jr. (1963) Recent meander belt deposits of the Brazos River: an alluvial "sand" model: Bull. Amer. Assoc. Petrol. Geol., vol. 47, p. 350.

-------, -------, Parrott, B. S., and LeBlanc, R. J., Sr. (1970) Recent sediments of southeast Texas--A field guide to the Brazos alluvial and deltaic plains and the Galveston Barrier Island complex: Univ. Texas, Bur. Econ. Geology Guidebook 11, 131 pp.

Berry, R. W. (1970) Mineralogy of the suspended sediment in the Tigris, Euphrates and Shatt-al-arab Rivers of Iraq, and the recent history of the Mesopotamian Plain: Jour. Sed. Petrology, vol. 40, pp. 131-139.

Bersier, A. (1958) Sequences detriques et divagations fluviales: Eclogae Geol. Helv., vol. 51, pp. 854-893.

Beutner, E. C., et al. (1967) Bedding geometry in a Pennsylvanian channel sandstone: Bull. Geol. Soc. Amer., vol. 78, pp. 911-916.

Bieber, C. L. (1953) Current directions indicated by crossbedding in deposits of early Mansfield age in southeastern Indiana: Indiana Acad. Sci. Proc., vol. 62, pp. 228-229.

Birkeland, P. W. (1968) Mean velocities and boulder transport during Tahoe-age floods of the Truckee River, California: Bull. Geol. Soc. Amer., vol. 79, pp. 137-142.

Bluck, B. J. (1971) Sedimentation in the meandering River Endrick: Scot. Jour. Geol., vol. 7, pp. 93-138.

-------, and Kelling, G. (1962) Channels from the Upper Carboniferous coal measures of South Wales: Sedimentology, vol. 2, pp. 29-53.

Boersma, J. R. (1967) Remarkable types of mega cross-stratification in the fluviatile sequence of a Subrecent distributary of the Rhine: Geol. en Mijnbouw, vol. 46, pp. 217-235.

Born, S. M., and Ritter, D. F. (1970) Modern terrace development near Pyamid Lake, Nevada, and its geologic implications: Bull. Geol. Soc. Amer., vol. 81, pp. 1233-1242.

Bouma, A. H. (1967) A study of the Colorado River and its delta in Matagorda Bay, in A report for the Attorney General's Office, Austin, Texas: Texas A&M Univ., Dept. of Oceanography.

Brice, J. C. (1964) Channel patterns and terraces of the Loup River in Nebraska: U.S. Geol. Survey Prof. Paper 422-D, 41 pp.

Brooks, N. H. (1955) Mechanics of streams with movable beds of fine sand: Amer. Soc. Civil Engrs. Proc., vol. 81, pp. 1-28.

Brown, L. F., Jr. (1969) Geometry and distribution of fluvial and deltaic sandstones (Pennsylvanian and Permian), north-central Texas: Gulf Coast Assoc. Geol. Socs. Trans., vol. 19, pp. 23-47. Reprinted as Univ. Texas, Bur. Econ. Geology Geol. Circ. 69-4.

Brush, L. M. (1964) Sediment sorting in alluvial channels: Bull. Amer. Assoc. Petrol. Geol., vol. 48., pp. 145-181.

Bruun, P. (1966) Model geology: prototype and laboratory streams: Bull. Geol. Soc. Amer., vol. 77, pp. 959-974.

-------(1968) Model geology: reply to Hoake: Bull. Geol. Soc. Amer., vol. 79, pp. 395-398.

Bull, W.B. (1964) History and causes of channel trenching in western Fresno County, California: Amer. Jour. Sci., vol 262, pp. 249-258.

Butler, B.E. (1958) Depositional systems of the Riverine Plain of southeastern Australia in relation to soils: Commonwealth Sci. and Indus. Res. Org., Australian Soil Pub. No. 10, 35 pp.

Cabot, E.C. (1947) The northern Alaska coastal plain interpreted from aerial photographs: Geog. Review, vol. 37, pp. 639-648.

Carey, W.C., and Keller, M.D. (1957) Systematic changes in the beds of alluvial rivers: Amer. Soc. Civil Engrs. Proc., Hydraulics Div. Jour., vol. 83, pp. 1-24.

Carlson, W. A., and Runnells, R.T. (1952) A study of silt deposited by the July 1951 flood, central Kansas River Valley: Kansas Acad. Sci. Trans., vol. 55, pp. 209-213.

Casshyap, S.M. (1970) Sedimentary cycles and environment of deposition of the Baraker Coal Measures of Lower Gondwana, India: Jour. Sed. Petrology vol. 40, pp. 1302-1317.

-------, and Qidwai, H.A. (1971) Paleocurrent analysis of lower Gondwana sedimentary rocks, Pench Valley, Madhya Pradesh, India: Sed. Geol., vol. 5, pp. 135-146.

Challinor, J. (1946) Two contrasted types of alluvial deposits: Geol. Mag., vol. 83, pp. 162-164.

Chien, H.Y. (1967) Hydraulics of rivers and deltas: Colorado State Univ., Ph. D. Dissertation, 176 pp.

Chien, N. (1961) The braided stream of the lower Yellow River : Sic. Sinica (Peking), vol. 10, pp. 734-754.

Christiansen, J.E. (1953) Distribution of silt in open channels: Amer. Geophys. Union Trans., vol. 16, pp. 478-485.

Colby, B.R. (1963) Fluvial sediments--a summary of transportation, deposition and measurement of sediment discharge: U.S. Geol. Survey Bull. 1181-A, pp. 1-47.

-------(1964a) Discharge of sands and mean-velocity relationships in sand bed streams: U.S. Geol. Survey Prof. Paper 462-A, 47 pp.

-------(1964b) Scour and fill in sand bed streams: U.S. Geol. Survey Prof. Paper 462-D, 32 pp.

Coleman, J.M. (1969) Brahmaputra River: channel processes and sedimentation: Sed. Geology (special issue), vol. 3, pp. 129-237.

Collinson, J.D. (1970) Bedforms in the Tana River, Norway: Geog. Annaler., vol. 52, pp. 31-56.

Craig, L.C., et al. (1955) Stratigraphy of Morrison and related formations, Colorado Plateau Region: a preliminary report: U.S. Geol. Survey Bull. 1009-E, pp. 125-168.

Crickmay, C.H. (1960) Lateral activity in a river of northwestern Canada: Jour. Geology, vol. 68, pp. 377-391.

Croft, A. (1962) Some sedimentation phenomena along the Wasatch Mountain Front: Jour. Geog. Rev., vol. 67, pp. 1511-1524.

Crouzel, F. (1957) Le Miocene continentale du bassin d'Aquitaine: Bull. Serv. Carte Geol. France, vol. 248, 264 pp.

Culbertson, J.K., and Dawdy, D.R. (1964) A study of fluvial characteristics and hydraulic variables, Middle Rio Grande, New Mexico: U.S. Geol. Survey Water Supply Paper 1498-F, 74 pp.

Davies, W.K. (1966) Sedimentary structures and subfacies of a Mississippi River point bar: Jour. Geology, vol. 74, pp. 234-239.

Davis, W.M. (1889) The rivers and valleys of Pennsylvania: Natl. Geog. Mag., vol. 1, pp. 183-253.

-------(1938) Sheetfloods and streamfloods: Bull. Geol. Soc. Amer., vol. 49, pp. 1337-1416.

Doeglas, D.J. (1962) The structure of sedimentary deposits of braided rivers: Sedimentology, vol. 1, pp. 167-190.

Donaldson, A.C. et al, (1969) Some Appalachian coals and carbonates models of ancient shallow-water deposition: West Virginia Geol. Survey Spec. Pub., 384 pp.

Doty, R.W., and Hubert, J.F. (1962) Petrology and paleogeography of the Warrensburg channel sandstone, western Missouri: Sedimentology, vol. 1, pp. 7-39.

Drew, F. (1873) Alluvial and lacustrine deposits and glacial records of the upper Indus Basin: Quart. Jour. Geol. Soc. London, vol. 90, pp. 441-471.

Drury, W.H. (1956) Bog flats and physiographic processes in the upper Kuskokwim River region, Alaska: Harvard Univ., Gray Herbarium Contrib. 178, 130 pp.

Duff, P. McL. D., et al. (1967) Cyclic sedimentation, in Cycles in fluvial regimes, chapter 2 of Developments in Sedimentology, vol. 10: Elsevier Pub. Co., Amsterdam, pp. 21-47.

Fahnestock, R.K. (1969) Morphology of the Slims River: Icefield Ranges Res. Proj. Scientific Results, vol. 1, pp. 161-172.

Feofilova, A.P. (1954) The place of alluvium in sedimentation cycles of various orders and time of its formation: Akad. Nauk SSSR Geol. Inst. Trans. no.151, Coal Ser. no. 5, pp. 241-272 (in Russian).

Ferm, J.C. (1962) Petrology of some Pennsylvanian sedimentary rocks: Jour. Sed. Petrology, vol. 32, pp. 104-123.

Finch, W.I. (1959) Geology of uranium deposits in Triassic rocks of the Colorado Plateau region: U.S. Geol. Survey Bull. 1074-D, 164 pp.

Fisher, W.L. (1969) Facies characterization of Gulf Coast Basin delta systems, with some Holocene analogues: Gulf Coast Assoc. Geol. Socs. Trans., vol. 19, pp. 239-261.

-------, and McGowen, J.H. (1967) Depositional systems in the Wilcox Group of Texas and their relationship to occurrence of oil and gas: Gulf Coast Assoc. Geol. Socs. Trans., vol. 17, pp. 105-125.

Fisk, H.N. (1944) Geological investigation of the alluvial valley of the Lower Mississippi River: Mississippi River Comm., Vicksburg, 78 pp.

-------(1947) Fine grained alluvial deposits and their effects on Mississippi River activity: Mississippi River Comm., Vicksburg, 82 pp.

Folk, R.L., and Ward, W.C. (1957) Brazos River bar--a study in the significance of grain size parameters: Jour. Sed. Petrology, vol. 27, pp. 3-26.

Frazier, D.E., and Osanik, A. (1961) Point-bar deposits, Old River Locksite, Louisiana: Gulf Coast Assoc. Geol. Socs. Trans., vol 11, pp. 127-137.

Friedkin, J.F. (1945) A laboratory study of the meandering of alluvial rivers: U.S. Waterways Exper. Sta., Vicksburg, Miss., 40 pp.

Friedman, G.M. (1961) Distinction between dune, beach, and river sands from their textural characteristics: Jour. Sed. Petrology, vol. 31, pp. 514-529.

Friedman, S.A. (1960) Channel-fill sandstones in the middle Pennsylvanian rocks of Indiana: Indiana Geol. Survey Rept. Prog. 23, 59 pp.

Friend, P.F. (1965) Fluviatile sedimentary structures in the Woodbay Series (Devonian) of Spitsbergen: Sedimentology, vol. 5, pp. 39-68.

Gagliano, S.M., and van Beek, J.L. (1970) Hydrologic and geologic studies of coastal Louisiana, in Geology and geomorphic aspects of deltaic processes, Mississippi Delta System, pt. 1, vol. 1: Coastal Studies Inst. and Dept. Marine Sciences, Louisiana State Univ., Baton Rouge, 140 pp.

Galloway, W.E., and Brown, L.F., Jr. (1972) Depositional system and shelf-slope relationships in upper Pennsylvanian rocks, north-central Texas: Univ. Texas, Bur. Econ. Geology Rept. of Investigation 75.

Gibbs, R.J. (1967) Geochemistry of the Amazon River System, part I: The factors that control the salinity and composition and the concentration of the suspended solids: Bull. Geol. Soc. Amer., vol. 78, pp. 1203-1232.

Gilbert, G.K. (1914) The transportation of debris by running water: U.S. Geol. Survey Prof. Paper 86, 263 pp.

Glen, J.L., and Dahl, A.R. (1959) Characteristics and distribution of some Missouri River deposits: Iowa Acad. Sci. Proc., vol. 66, pp. 301-311.

Guy, H.P., et al. (1966) Summary of alluvial channel data from flume experiments, 1956-61: U.S. Geol. Survey Prof. Paper 462-I, pp. II-I96.

Gwinn, V.E. (1964) Deduction of flow regime from bedding characteristics in conglomerates and sandstones: Jour. Sed. Petrology, vol. 34, pp. 656-658.

-------(1968) Divergence between dip directions of cross-strata and enclosing cross-strata boundaries: a characteristic of alluvial point bar sands (abst.): Bull. Amer. Assoc. Petrol. Geol., vol. 52, p. 530.

Happ, S.C. (1948) Sedimentation in the middle Rio Grande Valley, New Mexico: Bull. Geol. Soc. Amer., vol. 59, pp. 1191-1215.

-------, et al. (1940) Some aspects of accelerated stream and valley sedimentation: U.S. Dept. Agric. Tech. Bull. 695, 134 pp.

Harms, J. C. et al. (1963) Stratification in modern sands of the Red River, Louisiana: Jour. Geology, vol. 76, pp. 566-580.

Harms, J. C., and Fahnestock, R. K. (1965) Stratification, bedforms, and flow phenomena (with examples from the Rio Grande), in Primary sedimentary structures: Soc. Econ. Pal. Min. Spec. Pub. 12, pp. 84-115.

Hickin, E. J. (1969) A newly identified process of point bar formation in natural streams: Amer. Jour. Sci., vol. 267, pp. 999-1010.

Hjulstrom, F. (1939) Trsnsportation of detritus by moving water: Soc. Econ. Pal. Min. Spec. Pub. 4, pp. 5-31.

Hoake, R. L. (1968) Model geology: prototype and laboratory streams: discussion: Bull. Geol. Soc. Amer., vol. 79, pp. 391-394.

Hopkins, M. E. (1958) Geology and petrology of the Anvil Rock Sandstone of southern Illinois: Illinois Geol. Survey Circ. 256, 49 pp.

Jahns, R. H. (1947) Geologic features of the Connecticut Valley, Massachusetts, as related to recent floods: U. S. Geol. Survey Water Supply Paper 996, 158 pp.

Jones, D. J. (1954) Sedimentary features and mineralization of the Salt Wash Sandstone at Cove Mesa, Carrizo Mountains, Apache Co., Arizona: U.S. Atomic Energy Comm. Tech. Rept. RME 3093 (pt. 2), 40 pp.

Karcz, I. (1970) Development of a meandering Thalweg in a straight, erodable laboratory channel: Jour. Geology, vol. 78, pp. 234-240.

Kartashov, I. P. (1961) Facies, dynamic phases and formation of alluvium: Izv. Akad. Nauk SSSR Ser. Geol., vol. 9, pp. 77-90 (in Russian).

Kidson, C. (1953) The Exmoor storm and the Lynmouth floods: Geography, vol. 38, pp. 1-9.

Klein, G. deV., editor (1968) Late Paleozoic and Mesozoic continental sedimentation, northeastern North America: Geol. Soc. Amer. Spec. Paper 106.

Kukal, Z., and Al-Jassim, J. (1971) Sedimentology of Pliocene molasse sediments of the Mesopotamian geosyncline: Sed. Geology, vol. 5, pp. 57-81.

Laming, D. J. C. (1966) Imbrication, paleocurrents, and other sedimentary features in the Lower New Red Sandstone, Devonshire, England: Jour. Sed. Petrology, vol. 36, pp. 940-959.

Lane, D. W. (1963) Cross stratification in San Bernard River, Texas, point bar deposits: Jour. Sed. Petrology, vol. 33, pp. 350-354.

Lattman, L.H. (1960) Cross-section of a floodplain in a moist region of moderate relief: Jour. Sed. Petrology, vol. 30, pp. 275-282.

Lebededna, N.V. (1966) Change in grain size of Recent channel alluvium downward along the course of a plains river (as observed from the Vycheyde River): Lithology and mineral resources, vol. 1, pp. 585-592.

Leliavsky, Serge (1966) An introduction to fluvial hydraulics: Dover Publications, New York, 257 pp.

Lemcke, K., et al. (1953) Geologische und sedimentpetrographische untersuchungen im Westteil der ungefalteten Molasse des Suddeutschen Alpervorlandes: Geol. Jahrb., Beih. 11, 110 pp.

Leopold, L.B., et al. (1964) Fluvial processes in geomorphology: Freeman and Company, San Francisco, 522 pp.

-------, and Langbein, W.B. (1966) River meanders: Sci. Amer., vol. 214, pp. 60-70.

-------, and Wolman, M.G. (1957) River channel patterns: braided, meandering, and straight: U.S. Geol. Survey Prof. Paper 282-B, pp. 39-85.

Lorens, P.J., and Thronson, R.C. (1955) Geology of the fine grained alluvial deposits in Sacramento Valley and their relationship to seepage, in Seepage conditions in Sacramento Valley: Water Proj. Authority Calif. Rept., pp. A1-A26.

McGowen, J.H., and Garner, L.E. (1969) Camparison of Recent and ancient coarse-grained point bars (abst.): Bull. Amer. Assoc. Petrol. Geol., vol. 53, pp. 731-732.

-------, and ------- (1970) Physiographic features and stratification types of coarse-grained point bars: modern and ancient examples: Sedimentology, vol. 14, pp. 77-111.

-------, and Groat, C.G. (1971) Van Horn sandstone, West Texas: An alluvial fan model for mineral exploration: Univ. Texas, Bur. Econ. Geol. Rept. of Investigation 72, 57 pp.

McKee, E.D., Evanson, C.G., and Grundy, W.D. (1953) Studies in sedimentology of Shinarump Conglomerate of northeastern Arizona: U.S. Atomic Energy Comm. Rept. RME-3089, 48 pp.

-------, et al. (1967) Flood deposits, Bijou Creek, Colorado, June 1965: Jour. Sed. Petrology, vol. 37, pp. 829-851.

Mackin, J.H. (1948) Concept of the graded river: Bull. Geol. Soc. Amer., vol. 59, pp. 463-512.

------- (1956) Causes of braiding by a graded river (abst.): Bull. Geol. Soc. Amer., vol. 67, pp. 1717-1718.

Martin, W.D., and Henniger, B.R. (1969) Mather and Hockingport sandstone lentils (Pennsylvanian and Permian) of Dunkard Basin, Pennsylvania, West Virginia and Ohio: Bull. Amer. Assoc. Petrol. Geol., vol. 53, pp. 279-298.

Melton, F.A. (1936) An empirical classification of floodplain streams: Geog. Rev., vol. 26, pp. 593-610.

Middleton, G.V. (1967) Experimental and field studies on the genesis of sandstones, in Symposium on recently developed geologic principles and sedimentation of the Permo-Pennsylvanian of the Rocky Mountains: Wyoming Geol. Assoc., 20th ann. conf., pp. 23-29c, Casper.

Moody-Stuart, M. (1966) High-and low-sinuosity stream deposits, with examples from the Devonian of Spitsbergen: Jour. Sed. Petrology, vol. 36, pp. 1102-1117.

Morisawa, M. (1968) Streams, their dynamics and morphology: McGraw-Hill, New York, 175 pp.

Mudge, M.R. (1956) Sandstones and channels of the Upper Pennsylvanian and Lower Permian in Kansas: Bull. Amer. Assoc. Petrol. Geol., vol. 40, pp. 654-678.

Mundt, P.A. (1956) Heath-Amsden strata in central Montana: Bull. Amer. Assoc. Petrol. Geol., vol. 40, pp. 1915-1934.

NEDECO (Netherlands Engineering Consultants) (1959) River studies and recommendations on improvement of Niger and Benue: North-Holland, 1000 pp., Amsterdam.

Ore, H.T. (1963a) The braided stream depositional environment: Univ. Wyoming, Ph.D. Dissertation, 205 pp.

------- (1963b) Some criteria for recognition of braided stream deposits: Univ. Wyoming, Contributions to Geology, vol. 3, pp. 1-14.

-------(1965) Characteristic deposits of rapidly aggrading streams: Wyoming Geol. Assoc., 19th field conf. guidebook, pp. 195-201.

Pelletier, B.R. (1958) Pocono paleocurrents in Pennsylvania and Maryland: Bull. Geol. Soc. Amer., vol.69, pp. 1033-1064.

Pepper, J.R., et al. (1954) Geology of the Bedford Shale and Berea Sandstone in the Appalachian Basin: U.S. Geol. Survey Prof. Paper 259, 111 pp.

Pettijohn, F.J., and Potter, P.E. (1964) Atlas and Glossary of primary sedimentary structures: Springer-Verlag, Berlin, 370 pp.

-------, -------, and Siever, R. (1965) Geology of sand and sandstone: Indiana Univ., Indiana Geol. Survey and Dept. of Geology Spec. Pub., 205 pp.

Picard, M.D. (1957) Criteria used for distinguishing lacustrine and fluvial sediments in Tertiary beds of Uinta Basin, Utah: Jour. Sed. Petrology, vol. 27, pp. 373-377.

Potter, P.E. (1962a) Late Mississippian sandstones of Illinois: Illinois Geol. Survey Circ. 340, 36 pp.

-------(1962b) Shape and distribution patterns of Pennsylvanian sand bodies in Illinois: Illinois Geol. Survey Circ. 339, 36 pp.

-------(1962c) Regional distribution patterns of Pennsylvanian sandstones in Illinois Basin: Bull. Amer. Assoc. Petrol. Geol., vol. 46, pp. 1890-1911.

-------(1963) Late Paleozoic sandstones of the Illinois Basin: Illinois Geol. Survey Rept. Inv. 217, 92 pp.

-------(1967) Sand bodies and sedimentary environments: a review: Bull. Amer. Assoc. Petrol. Geol., vol. 51, pp. 337-365.

-------, and Blakely, R.F. (1967) Generation of a synthetic vertical profile of a fluvial sandstone body: Soc. Petrol. Engr. Jour., vol. 7, pp. 243-251.

-------, and Pettijohn, F.J. (1963) Paleocurrents and basin analysis: Springer-Verlag, Berlin, 296 pp.

Read, W.A. (1969) Fluviatile deposits in Namurian rocks of central Scotland: Geol. Mag., vol. 106, pp. 331-473.

Reynolds, D.W., and Vincent, J.K. (1967) Western Kentucky's Bethel channel--the largest continuous reservoir in the Illinois basin, in Rose, W.D., ed., Proc. of technical sessions, Kentucky Oil and Gas Assoc., 29th ann. mtg.: Kentucky Geol. Survey Spec. Pub. 14, ser. 10, pp. 19-30.

Royse, C.F., Jr. (1968) Recognition of fluvial environments by particle-size characteristics: Jour. Sed. Petrology, vol. 38, pp. 1171-1178.

Royse, C.F., Jr. (1970) A sedimentological analysis of the Tongue River--Sentinel Butte interval (Paleocene) of the Williston Basin, western North Dakota: Sed. Geology, vol. 4, pp. 19-80.

Rubey, W.W. (1938) The force required to move particles on a stream bed: U.S. Geol. Survey Prof. Paper 189-E, pp. 121-141.

-------, and Bass, N.W. (1925) The geology of Russell County, Kansas: Kansas Geol. Survey Bull. 10, pp. 57-62.

Russell, R.J. (1954) Alluvial morphology of Anatolian rivers: Amer. Assoc. Geog., vol. 32, pp. 149-254.

------- (1967) River and delta morphology: Louisiana State Univ., Coastal Studies Inst. Tech. Rept. No. 52, 55 pp.

Sarkar, S.K., and Basumallick, S. (1968) Morphology, structure, and evolution of a channel island in the Barakar River, Barakar, West Bengal: Jour. Sed. Petrology, vol. 38, pp. 746-754.

Saucier, R.T., and Kolb, C.R. (1967) Alluvial geology of the Yazoo Basin, Lower Mississippi Valley: U.S. Army Engrs. Waterways Exper. Sta., Vicksburg, Miss. (Summary maps and description of environments from Tech. Rept. 3-480 by C.R. Kolb, et al.)

Schideler, G.L. (1969) Dispersal patterns of Pennsylvanian sandstones in the Michigan Basin: Jour. Sed. Petrology, vol. 39, pp. 1229-1237.

Schlee, J.S., and Moench, R.H. (1961) Properties and genesis of Jackpile Sandstone, Laguna, New Mexico, in Geometry of sand bodies: Amer. Assoc. Petrol. Geol. Spec. Pub., pp. 134-150.

Schmudde, T.H. (1963) Some aspects of land forms of the lower Missouri River floodplain: Ann. Assoc. Amer. Geog., vol. 53, pp. 60-73.

Schumm, S.A. (1960) The shape of alluvial channels in relation to sediment type: U.S. Geol. Survey Prof. Paper 352-B, pp. 17-30.

-------(1968) Speculations concerning paleohydrologic controls of terrestrial sedimentation: Bull. Geol. Soc. Amer., vol. 79, pp. 1573-1588.

Selley, R.C. (1965) Diagnostic characters of fluviatile sediments of the Torridonian Formation (Precambrian) of northwest Scotland: Jour. Sed. Petrology, vol. 35, pp. 366-380.

Shantser, E. V. (1951) Alluvium of the river plains of the temperate zone and its significance for the knowledge of regularities of structure and formation of alluvial deposits: Akad. Nauk SSSR Geol. Inst. Trans. No. 135, Geol. Ser. 55, 273 pp. (Russian)

Shelton, J. W. (1967) Stratigraphic models and general criteria for recognition of alluvial, barrier bar, and turbidity current sand deposits: Bull. Amer. Assoc. Petrol. Geol., vol. 51, pp. 2441-2461.

Simon, J. A., and Hopkins, M. E. (1966) Sedimentary structures and morphology of late Paleozoic sand bodies in southern Illinois: Amer. Assoc. Petrol. Geol. Field Guidebook and Guidebook Series 7, Illinois Geol. Survey, 67 pp.

Simons, D. B., and Richardson, E. V. (1961) Forms of bed roughness in alluvial channels, in Primary sedimentary structures: Soc. Econ. Pal. Min. Spec. Pub. 12, pp. 34-52.

-------, et al. (1965) Sedimentary structures generated by flow in alluvial channels, in Primary sedimentary structures: Soc. Econ. Pal. Min. Spec. Pub. 12, pp. 34-52.

Smith, N. D. (1970) The braided stream depositional environment: comparison of the Platte River with some Silurian clasitc rocks, north-central Appalachians: Bull. Geol. Soc. Amer., vol. 81, pp. 2993-3014.

Stanley, D. J. (1968) Graded bedding-sole marking-graywacke assemblage and related sedimentary structures in some Carboniferous flood deposits, eastern Massachusetts: Geol. Soc. Amer. Spec. Paper 106, pp. 211-239.

Stokes, W. L. (1961) Fluvial and eolian sandstone bodies in Colorado Plateau, in Geometry of sandstone bodies: Amer. Assoc. Petrol. Geol. Spec. Pub., pp. 151-178.

------- (1967) Stratigraphy and primary sedimentary features of uranium occurrences of southeastern Utah, in Uranium districts of southeastern Utah: Utah Geol. Soc. Guidebook to geology of Utah, no. 21, pp. 32-52.

Stricklin, F. L., Jr. (1961) Degradational stream deposits of the Brazos River, central Texas: Bull. Geol. Soc. Amer., vol. 72, pp. 19-36.

Sundborg, A. (1956) The River Klaralven: a study of fluvial process: Geog. Ann., vol. 38, pp. 127-316.

Sutton, J., and Watson, J. (1960) Sedimentary structures in the Epidote Grits of Skye: Geol. Mag., vol. 97, pp. 106-122.

Thom, B.G. (1967) Coastal and fluvial landforms--Horry and Marion Counties, South Carolina: Louisiana State Univ., Coastal Studies Inst. Tech. Rept. No. 44, 75 pp.

Visher, G.S. (1965a) Fluvial processes as interpreted from ancient and Recent fluvial deposits, in Primary sedimentary structures: Soc. Econ. Pal, Min. Spec. Pub. 12, pp. 116-132.

Visher, G.S. (1965b) Use of vertical profile in environmental reconstruction: Bull. Amer. Assoc. Petrol. Geol., vol. 49, pp. 41-61.

Wanless, H.R. (1923) The stratigraphy of the White River Beds of South Dakota: Amer. Philos. Soc. Proc., vol. 62, pp. 190-269.

Whetten, J.T., and Fullam, T.J. (1967) Columbia River bed forms: Internat. Assoc. Hydraulic Res. Proc., vol. 1, pp. 107-114.

Williams, E.G., and Ferm, J.C. (1964) Sedimentary facies in the Lower Allegheny rocks of western Pennsylvania: Jour. Sed. Petrology, vol. 34, pp. 610-614.

Williams, G.E. (1968) Formation of large-scale trough cross-stratification in a fluvial environment: Jour. Sed. Petrology, vol. 38, pp. 136-140.

Williams, P.F., and Rust, B.R. (1969) The sedimentology of a braided river: Jour. Sed. Petrology, vol. 39, pp. 649-679.

Wilson, C.W., Jr. (1948) Channels and channel-filling sediments of Richmond age in south-central Tennessee: Bull. Geol. Soc. Amer., vol. 59, pp. 733-766.

Wolman, M.G., and Leopold, L.B. (1957a) River channel patterns: braided, meandering, and straight: U.S. Geol. Survey Prof. Paper 282-B, pp. 39-85.

-------, and ------- (1957b) River flood plains: some observations on their formation: U.S. Geol. Survey Prof. Paper 282-C, pp. 87-107.

Yeakel, L.S., Jr. (1962) Tuscarora, Juniata, and Bald Eagle paleocurrents and paleogeography in the central Appalachians: Bull. Geol. Soc. Amer., vol. 73, pp. 1515-1540.

DELTA SYSTEMS -- Summary

1. Definition: irregular coastline resulting from progradation of terrigenous sediments; dip fed; regardless of importance of marine facies as part of system, a progradational facies must be maintained and preserved

2. Basic process: involves discharge of water with sediment load into a relatively standing body of water; interaction of fluvial and marine processes; commonly a river emptying into an oceanic body of water

3. Variables in delta formation

    a. Sediment input in terms of amount, caliber, rate, and variation in rate
    b. Nature of discharging and reservoir water bodies chiefly regarding relative water densities
    c. Reservoir energy (waves, currents, tides), especially in relation to amount of sediment input
    d. Depth of water into which delta is prograding
    e. Nature of substrate of reservoir body
    f. Structural nature of depositional basin

    Most significant variable involves interaction of fluvial and marine processes

    Constructive phase: fluvial or fluvially influenced processes dominant, not only in the debouching of load into reservoir body of water (delta-front bedload and prodelta suspended load) but in the development of a variety of subaerial environments on the delta plain (levees, distributary channels, crevasse splays, lakes, marshes, interdistributary floodbasins and bays); construction involves progradation and aggradation

    Destructive phase: marine processes dominant, chiefly reworking and redistribution of fluvially introduced sediments; may be restricted chiefly to abandonment of delta lobe or may be contemporaneous with fluvial progradation where marine energy relatively high

4. Delta hydrodynamics

    a. Jet theory: assumes with stream in equilibrium, amount and type of sediment transported is function of stream velocity; flow through defined orifice; exist when stream discharges into a standing body of water
    b. Types of jet flow: axial and plane; in axial, mixing takes place in three dimensions, rapid decrease in velocity, frontal boundary maintains uniform angle of about 20°; in plane jet, mixing in only two dimensions, less marked decrease in velocity, frontal boundary

shows decreasing angle

c. Types of resulting deltas:

Hyperpyncnal inflow: inflow more dense than reservoir; caused by sediment load, higher salinity, colder water; discharge flows down side of basin as an underflow or turbidity current; plane jet

Homopyncnal inflow: inflow equally as dense as reservoir; ready mixing in three dimensions; conditions common when stream empties into lake; result is a Gilbert-type delta with well developed top-, fore-, and bottom-set beds; axial jet

Hypopyncnal inflow: inflow less dense than reservoir; sediment-laden fluid moves out over surface of reservoir; plane jet; small discharge gives small lunate bar, moderate to large discharge gives a channel-mouth bar; common to rivers emptying into sea-water reservoirs; bedload dropped at channel mouth, builds up bar that blocks channel, bar is breached marginally giving rise to distributaries; suspended load carried seaward, but most dropped within 15 miles of channel mouth

5. Basic delta types:

High-constructive systems: formed by progradation of large streams with large sediment load, commonly low bedload/suspended load ratio; progradational and aggradational facies make up bulk of system, formed chiefly through fluvial or fluvially influenced processes; little contemporaneous marine influence during active progradation, restricted chiefly to destructional phase on abandonment of delta lobe; marine destructional facies form volumetrically slight amount of total accumulation

Divided into high-constructive lobate and high-constructive elongate, depending on geometry of prograded delta facies

High-destructive systems: formed by progradation of relative small streams with moderate, commonly high bedload/suspended load ratio; marine processes dominant to fluvial processes; fluvially introduced sediments reworked and redistributed contemporaneous with active progradation; marine or destructive-type facies form volumetrically large amount of total accumulation

Divided into high-destructive wave dominated and high-destructive tide dominated, depending on principal marine process

6. Holocene examples:

High-constructive lobate: Lafourche, Teche, and St. Bernard deltas of Mississippi system

High-constructive elongate: Modern delta of Mississippi system; most small bayhead deltas

High-destructive wave dominated: Rhone, Po, Nile, Apalachicola, Surinam, Tabasco systems

High-destructive tide dominated: Mekong, Gulf of Papua, Irrawaddy, Yalu, Gulf of Cambay, Frazier

7. Principal delta environments and facies:

Constructive environments and facies: all show direct or indirect fluvial influence; involve progradation and aggradation; variety depends on basic type of delta; high-constructive deltas with greatest volume and variety; divided into framework elements (primarily sand facies, higher energy in system, form skeletal framework) and nonframework elements (chiefly mud and bedded organics, progradational off delta, aggradational on delta)

Framework elements: include fluvial channel and associated levee and delta front

Channel: in high-constructive deltas, commonly distributary or straight channel type; in high-destructive deltas, chiefly fine-grained meander-belt type (see fluvial summary)

Subaerial levee: best developed along straight distributary channels of high-constructive systems; formed by overbanking; height and extent owed to size of channel, flood heights, and suspended load; subaerial except during flood, well drained, vegetated, root mottling destroys primary sedimentary structures; asymmetrical, perpendicular to channel, crest adjacent to bank, outer margins grade to floodbasin; forms downdelta wedge, decreasing in height, thickness, and width; fine grained sediments, calcareous and ferruginous nodules common; in straight distributary will flank channel deposits, in meander-belt sands will overlie channel deposits

Delta front: represents coarse sediments associated with delta advance, high sand; formed by drop of bedload on stream debouchment; relative abundance of this unit in delta systems as well as its external geometry essentially define different delta types; divided into following subunits:

Distributary-mouth bar: bar formed at immediate mouth of debouching stream; builds up as a shoal, breached marginally to give distributaries; may be scoured by flood currents; frontal face winnowed by wave action; sediments are clean sands with carbonaceous detritus, multidirectional cross bedding mostly troughs, oscillation and current ripples; log pattern inverted Xmas tree

Slope and distal delta front: seaward bar slopes, sands fine and drop out and grade to prodelta muds; bar slope 1° to 2°;

structures mostly small to moderate troughs, current ripples, and parallel laminations; some burrowing

Subaqueous levee: continuation of subaerial levees beyond marsh line; mostly sand and silt, local laminations of plant debris and clay; current structures dominant with some winnowing during low river stages

Sheet sands: delta-front sand units vary from elongate to lobate in geometry; this is a function of relative amount of marine redistribution as well as number of distributary-mouth bars; reworking by marine processes gives sheet sands that coalesce the bars, giving the lobate delta-front sand facies

Nonframework units: above framework sand units form skeleton of delta, flesh of delta built of variety of sand, mud, and organic deposits; occur seaward of delta front as prodelta (progradational) and on delta as delta-plain facies (aggradational units including floodbasin, interdistributary bay, crevasse splay, marshes, swamps, lakes, abandoned channel fill)

Prodelta: form off river mouths seaward of delta front; mostly fines from suspension; initial progradation unit in basin; fluvially influenced but entirely below sea level (mostly at depths greater than 90 feet); most homogeneous and commonly widespread of all delta facies in high-constructive types thickest unit; mostly laminated either texturally or in color; dark muds, highly organic in high-constructive systems; deposited as high-water muds, sand units prograding these muds commonly show diapiric, compactional, and gas-heave structures; prolific source beds in high-constructive systems

Delta plain: well developed facies in high-constructive systems with great variety of environmental types; represent aggradation primarily between active channels or as fill of abandoned channels; geometry not defining, must use specific biologic, lithologic, and structural criteria along with facies association; mainly mud and organic facies

Abandoned channel: distributary channels commonly abandoned by avulsion, former channel plugged; further deposition from overbank suspension; result is long ribbon of mud abruptly overlying channel sands; mostly laminated but may be burrowed; organics may be common

Marsh and swamp: important environments in high-constructive systems, giving characteristic peats, lignites, coals; broad area constructed chiefly of muds at nearly sea level; organic growth in place with compactional subsidence leads to significant organics; zoned, swamps in upper part of delta plain, fresh-water marshes distal to swamps and flanking active streams; brackish marshes distal from fresh-water marshes, salt marshes along distal parts of delta plain; brackish marshes yield purest and thickest organics, away from terrigenous contamination near streams and marine destruction along distal parts of delta plain; organics local, between channels during active stage, may cover as areally extensive blanket deposits during delta-plain abandonment; may be broad in extent in high-destructive systems (e.g., tidal mangroves) but not significant in accumulation

Interdistributary bay: situated in distal parts of delta, between distributaries and at least partly connected to open sea; generally short lived; fine grained sediments, commonly fossiliferous and burrowed

Lakes: standing bodies of fresh water that form extensively between active distributaries and especially on delta abandonment; accumulation chiefly muds, may be burrowed; commonly infilled with Gilbert-type deltas

Crevasse splay: major source of coarse-textured, nonchannel deposits in delta plain; form from breach in main channel during flood, some bedload sediment carried through breach across levee and into flanking bay or floodbasin

Floodbasin: generally result in ponding flanking marshes during overflow of flood; chiefly source of mud deposition on delta plain; commonly laminated muds, may be burrowed or root mottled, alternate commonly with fresh-water marshes or swamp deposits

Destructive environments and facies: formed exclusively from marine processes, reworking of fluvially introduced sediments, in high-constructive systems chiefly temporally distinct, forming on delta abandonment; in vertical sequence a thin but areally extensive tract of facies alternating with thick constructive facies; in high-destructive systems may form the bulk of delta facies

Coastal barriers and delta-margin islands: in high-destructive wave-dominated systems, sands dropped at channel mouth are chiefly reworked by waves and thrown up as a series of coastal sand barriers distal to delta plain; these accrete seaward as a series of more or less cuspate sand ridges, contemporaneous with active progradation; on abandonment reworking continues until entire delta is foundered; in high-constructive systems, marine reworking becomes dominant only on delta abandonment; a series of arcuate barriers or delta-margin islands are thrown up by reworking of underlying sandy delta-front deposits, these will transgress landward as delta founders

Tidal sand bars: in high-destructive tide-dominated systems, bedload dropped by debouching rivers is reworked and redistributed by flood and ebb tidal currents, giving a series of elongate sand bars radiating from river mouth

Bay, sound, and lagoon: in wave-dominated systems narrow, elongate bays and lagoons form between accreting sand ridges; landward of these ridges coastal marine basins are common, these having some connection with the open sea; in destructive phase of high-constructive systems, sounds and bays form landward of the delta-margin islands; not significant in tide-dominated systems

Shelf: in destructive phase of high-constructive systems and seaward of high-destructive systems in all stages, little terrigenous sedimentation occurs; deposits are extensively burrowed and may carry abundant fossils

Inland facies: in destructive phase of high-constructive systems, inland areas of abandoned delta lobes are marked by extensive marshes, swamps, and lakes; delta plain of high-destructive tide-dominated systems are commonly occupied by mangroves or, in their absence, by tidal flats; in destructive phase of wave-dominated systems, inland parts of the delta lobe may be extensively embayed

8. Salient features of high-constructive and high-destructive delta systems

a. High-constructive delta systems	b. High-destructive delta systems
1. Source: distant, inland, continental interior; on order of 2,000 miles; fluvial system and facies concentrated along edge of depositional basin; streams heading delta system meandering	1. Source: local, basin margin; order of 200 miles; fluvial system and facies relatively uniformly developed along edge of depositional basin; streams heading delta system meandering and braiding
2. Sediment input: high volume and more or less continuous rate of input; distinct phases of construction and destruction; pronounced coastal progradation	2. Sediment input: moderate volume and sporadic rate of input; constructional and destructional phases interrelated and not vertically distinct; slight to moderate coastal progradation
3. Constructional facies: well-developed and extensive constructional sequences (progradational and aggradational); thick delta-plain deposits; numerous lignites, peats, or coals; distributary channels chiefly straight and bounded by well-developed levees	3. Constructional facies: constructional sequences local and areally restricted; in situ carbonaceous deposits not well developed; distributary channels generally of meander-belt type

4. *Destructional facies*: marine destruction commonly restricted to distal part of constructed delta mass; landward destruction marked by extensive peat or marsh deposits; temporally and vertically distinct from constructional facies; relatively low proportion of destructional sediments in delta system	4. *Destructional facies*: extensive, developed contemporaneously with construction; marine transgressions commonly far inland with extensive shallow embayments; commonly associated with nondeltaic (strandplain, coastal barrier) systems; high proportion of marine reworked sediments in delta systems
5. *Associated systems*: commonly large-scale, laterally associated (down longshore drift), and principally including strandplain, barrier-bar, and lagoonal systems	5. *Associated systems*: generally cannot support large-scale laterally associated depositional systems; local barrier-bar and strandplain facies included in delta system
6. *Delta-flank systems*: well developed as independent systems	6. *Delta-flank systems*: poorly developed as independent systems
7. *Prodelta*: thick, commonly the thickest facies of delta system	7. *Prodelta*: relatively thin, generally no thicker than other delta facies and commonly indistinguishable from nondeltaic shelf muds
8. *Shape*: lobate to elongate; main axes perpendicular to regional depositional strike; numerous lobes	8. *Shape*: chevron to cuspate with axes subparallel as well as perpendicular to regional depositional strike; few lobes
9. *Sand/mud ratio*: commonly low, results in common differential-compaction features; mud diapirs; stabilization of distributaries with prominent levee development	9. *Sand/mud ratio*: relatively high; distributaries commonly not well stabilized; muddy aggradational deposits not well developed as part of delta-plain facies

9. Mineral resources: Delta systems and component facies are the principal oil and gas reservoirs in clastic-filled basins, representing perhaps nearly 80% of all production from these basins. (1) Deltas make up large volumes of thick and areally extensive sands providing potential reservoirs. (2) Deltas have high *in situ* organic productivity contributing to potential source beds. (3) Deltas are characterized by rapid and large-volume deposition, which emphasizes structural features and differential compactional subsidence as potential traps; stratigraphic variations in sands result in potential stratigraphic traps. (4) Deltas result in juxtaposition of facies with contrasting formation waters coupled with rapid deposition of high water-content muds that together provide requisite geochemical facies and gradients for hydrocarbon conversion and hydro-

dynamic conditions effective in migration of sediment hydrocarbons.

Most of the world's important coal measures are component facies of high-constructive delta systems, with principal accumulation in delta-plain facies. Geochemical gradients significant in hydrocarbon conversion appear also to be important in mineralization of a wide host of base metals.

DELTA SYSTEMS

Selected References

Abbas, B. M. (1966) Control of floods in East Pakistan, *in* Scientific Problems of the humid Tropic Zone Deltas and Their Implications: UNESCO, Proc. Dacca Sym., pp. 135-141.

Adams, J. E., *et al.* (1951) Starved Pennsylvanian Midland Basin: Bull. Amer. Assoc. Petrol. Geol., vol. 35, pp. 2600-2607.

Albertson, M. L., Dai, Y. B., Jensen, R. A., and Rouse, H. (1950) Diffusion of submerged jets: Amer. Soc. Civil Engrs. Trans., vol. 115, pp. 639-697.

Ali, S. I. and Laming, D. J. C. (1966) The Alma River intertidal delta in the Bay of Fundy at Alma, New Brunswick: Maritime Sediments, vol. 2, pp. 3-5.

Allen, J. R. L. (1960) The Mam Tor sandstones, a "turbidite" facies of the Namurian deltas of Derbyshire England: Jour. Sed. Petrology, vol. 30, pp. 193-208.

------- (1964) Sedimentation in the modern delta of the river Niger, West Africa, *in* Developments in Sedimentology, vol. 1, Deltaic and Shallow Marine Deposits: Elsevier, Amsterdam, pp. 27-34.

------(1965a) Late Quaternary Niger Delta and adjacent areas; sedimentary environments and lithofacies: Bull. Amer. Assoc. Petrol. Geol., vol. 49, pp. 547-600.

------(1965b) Coastal geomorphology of eastern Nigeria--beach-ridge barrier islands and vegetated tidal flats: Geol. en Mijnbouw, The Hague, vol. 27, n.s., pp. 1-21.

------- (1970) Sediments of the modern Niger delta: Summary and review: Soc. Econ. Pal. Min. Spec. Pub. 15, pp. 138-151.

------- and Friend, P. F. (1968) Deposition of the Catskill facies, Appalachian Region: with notes on some other Old Red Sandstone Basins: Geol. Soc. Amer. Spec. Paper 106, pp. 21-74.

Allen, Percival (1960) Deltaic cyclothems: Geol. Mag., vol. 100, p. 129.

Allison, J. C., Priest, R. M., et al. (1927) Conditions and prospects on the Colorado Delta: Eng. News-Rec., vol. 98, pp. 439-444.

Amirgaliev, N. A. (1966) Some problems related to the hydrochemical regime of the Ural River Delta (trans.), in Fish resources of the Kazakhstan bodies of water and their exploitation: Nauka I Chelovechestro, no. 5, pp. 46-57 (in Russian).

Anderson, F. M. (1938) Lower Cretaceous deposits in California and Oregon: Geol. Soc. Amer. Spec. Paper 16, 339 pp.

------- (1945) Knoxville series in the California Mesozoic: Bull. Geol. Soc. Amer., vol. 56, pp. 909-1014.

Andresen, M. J. (1961) Geology and petrology of the Trivoli Sandstone in the Illinois Basin: Illinois Geol. Survey Circ. 316, 31 pp.

------- (1962) Paleodrainage patterns: their mapping from subsurface data and their paleogeographic value: Bull. Amer. Assoc. Petrol. Geol., vol. 46, pp. 398-406.

Anonymous (1875) Mouth of the Mississippi: Engineering, vol. 19, pp. 81-83.

------- (1923) Changes in the Nile Delta and lower Nile; The Delta lake fisheries: Geog. Review, vol. 13, pp. 618-620.

Arnborg, L. E. (1948) The delta of the Angerman River: Geograph. Ann., Stockholm, vol. 30, pp. 673-690.

------- (1959) The lower Anerman River: Part 2, Studies of fluvial morphology and processes in the Recent delta from 1947-58 (trans.): Uppsala Univ., Geograph. Inst. Pub. no. 2, 180 p. (in Swedish).

-------, Walker, R. J. and Peippo, J. (1962) Suspended load in the Colville River, Alaska: Louisiana State Univ., Coastal Studies Inst. Tech. Rept. No. 54, pp. 131-144.

Ascoli, F. D. (1910) Rivers of the delta: Asiatic Soc. Bengal Jour. and Proc., vol. 6, pp. 543-556.

Asquith, D. O. (1970) Depositional topography and major marine environments, Late Cretaceous, Wyoming: Bull. Amer. Assoc. Petrol. Geol., vol. 54, pp. 1184-1224.

Attia, M. I. (1954) Deposits in the Nile Valley and the Delta: Geol. Survey of Egypt, 356 pp.

Axelson, Valter (1955) The river Rapaalven, its delta and the sedimentation in Lake Laitaure: Uppsala Univ., Geograph. Inst., Medd. S. A., no. 99.

------- (1967) The Laitaure Delta, a study of deltaic morphology and processes: Geograph. Ann., Stockholm, vol. 49, pp. 1-127.

Bagchi, K. (1944) The Ganges Delta: Calcutta University Press, 157 p.

Baidin, S. S., and Skriplunov, N. A. (1960) Changes in the hydrological regime of the Volga estuarine region: Assoc. Internat. d'Hydrol. Sci. Bull. (Louvain), no. 20, pp. 51-55.

Baker, C. H. (1967) New observations on the Sheyenne Delta of glacial lake Agassiz: U. S. Geol. Survey Prof. Paper 575-B, pp. 62-68.

Bakker, W. T. J. N. P. and Edelman, T. (1965) The coast line of river-deltas: Conf. on Coastal Engr. Proc., 9th, pp. 199-218.

Baltzer, Frederic (1969) The floral association in the Dumbea River, New Caledonia and their ecologic, geomorphic, and sedimentologic interpretations as evidenced by a map (trans.): Off. Rech. Sci. Tech. Outre-Mer, Cahiers, Ser. Geol., vol. 1, pp. 59-84 (in French).

Banu, A. C. (1963) Some consequences of the secular rising of the Black Sea level on the morphohydrographic development of the Danube Delta (trans.): Hidrobiologia, Bucharest, vol. 4, pp. 109-128 (in Rumanian).

------- (1965) Contributions to the knowledge of the age and evolution of the Danube Delta (trans.): Hidrobiologia, Bucharest, vol. 6, pp. 259-278 (in Rumanian).

------- (1968) Deltas of the world (trans.): Bucharest, Natura, vol. 20, pp. 17-26 (in Rumanian).

------- and Buzeteanu, S. (1966) New data on recent geomorphological process in the Danube River Delta with particular stress on silting process (trans.): Hidrobiologia, Bucharest, vol. 7, pp. 255-266 (in Rumanian).

Barbour, G. B. (1935) Physiographic history of the Yangtze: China, Geol. Survey, Geol. Mem. no. 14, 103 pp., also, (1936) Geogr. Jour., London, vol. 87, pp. 17-34.

Barlow, J. A., Jr. and Haun, J. D. (1966) Regional stratigraphy of Frontier Formation and relation to Salt Creek Field, Wyoming: Bull. Amer. Assoc. Petrol. Geol., vol. 50, pp. 2185-2196.

Baroffio, J. R. (1964) Environmental mapping of the lower Allegheny Series of the Appalachian basin: University Microfilms, Inc., Ann Arbor, Michigan, 99 p.

Barrell, J. (1912) Criteria for the recognition of ancient delta deposits: Bull. Geol. Soc. Amer., vol. 23, pp. 377-466.

------- (1913) The Upper Devonian Delta of the Appalachian geosyncline: Amer. Jour. Sci., 4th ser., vol. 36, pp. 429-472.

------- (1914) The Upper Devonian delta of the Appalachian geosyncline: Amer. Jour. Sci., 4th ser., vol. 37, pp. 225-253.

Barton, D. C. (1930) Deltaic coastal plain of southeast Texas: Bull. Geol. Soc. Amer., vol. 41, pp. 359-382.

Bates, C. C. (1953) Rational theory of delta formation: Bull. Amer. Assoc. Petrol. Geol., vol. 37, pp. 2119-2162.

------- and Freeman, J. C., Jr. (1952) Inter-relations between jet behavior and hydraulic processes observed at deltaic river mouths and tidal inlets: Conf. on Coastal Engr. Proc., 3rd, pp. 165-175.

Batten, R. W. (1962) The sediments of the Beaufort Inlet area, North Carolina: Southeastern Geology, vol. 3, pp. 191-205.

Baulig, H. (1949) La vallee et le delta du Mississippi: Geograph. Ann., no. 311, pp. 220-232, no. 312, pp. 325-334.

Beerbower, J. R. (1961) Origin of cyclothems of the Dunkard Group (upper Pennsylvanian-lower Permian) in Pennsylvanian, West Virginia, and Ohio: Bull. Geol. Soc. Amer., vol. 72, pp. 1029-1050.

------- (1964) Cyclothems and cyclic depositional mechanisms in alluvial plain sedimentation: in Symposium on cyclic sedimentation, Part I: Kansas Geol. Survey Bull. 169, pp. 31-42.

Belevich, E. F. (1958) Fluctuations of the level of the Caspian and formation of the Volga Delta (trans.): Astrakhanskii Zapovednik, Trudy, no. 4 (in Russian).

------(1965a) Structure of the coastal area of the Volga Delta (trans.): Akad. Nauk SSSR, Geogr. Inst., Trudy, vol. 68 (in Russian).

------(1965b) A contribution to the history of the Volga Delta (trans.): Akad. Nauk SSSR, Okeanog. Komissiia, Trudy, vol. 1 (in Russian).

Belevich, Y. F. (1961) New Caspian deposits in the northwest part of the foremouth area of the Volga: Akad. Nauk SSSR, Doklady, Earth Sci. Sec., vol. 137, pp. 277-280 (English trans.).

------- (1969) Sedimentation in the foredelta of the Volga River: Oceanology, vol. 9, pp. 808-816 (English trans.).

Berg, C. R. (1969) Cherokee Group, west flank of the Nemaha Ridge: Shale Shaker, vol. 20, pp. 94-100.

Berg, C. V., Santema, P. and Thiadens, A. A. (1960) Geological and hydrological investigations in the delta area (trans.): Geol. en Mijnbouw, vol. 39, pp. 574-578 (in Dutch).

Berg, R. R. and Davies, D. K. (1970) Depositional environments of Muddy reservoir sandstones (Lower Cretaceous) in Powder River Basin, Montana and Wyoming (abs.): Bull. Amer. Assoc. Petrol. Geol., vol. 54, p. 835.

Berg, S. L. (1951) Basin morphological features of the Volga Delta (trans.): Moscow, Gosudarstvennyi Okeanograficheskii Institut, Trudy, vol. 18, no. 30 (in Russian).

Berman, L. Z. (1960) Types of small river mouths on the western shores of the Caspain (trans.): Akad. Nauk SSSR, Okeanog. Komissiia, Trudy, vol. 6 (in Russian).

Bernard, H. A. (1950) Quaternary geology of southeast Texas: Dissertation, Louisiana State Univ., Baton Rouge, 164 pp.

------- (1965) A résumé of river delta types (abs.): Bull. Amer. Assoc. Petrol. Geol., vol. 49, pp. 334-335.

------- and LeBlanc, R. J. (1965) Résumé of Quaternary geology of the northwestern Gulf of Mexico province in The Quaternary of the United States: Princeton University Press, pp. 137-185.

-------, Major, C. F., Jr., Parrott, B. S. and LeBlanc, R. J. (1970) Recent sediments of southeast Texas--A field guide to the Brazos alluvial and deltaic plains and the Galveston Barrier Island complex: Univ. Texas, Bur. Econ. Geol., Guidebook 11.

Berry, E. W. (1917) The delta character of the Tuscaloosa Formation: John Hopkins Univ. Circ., N.S. No. 3, pp. 216-222.

Berryhill, H. L., Jr. (1963) Geology and coal resources of Belmont County, Ohio: U. S. Geol. Survey Prof. Paper 380, 113 pp.

------- (1967) Allegheny region in Paleotectonic investigation of the Permian System in the United States: U. S. Geol. Survey Prof. Paper 515, pp. 1-7.

Bersier, A. (1958) Sequences detritiques et divagations fluviales: Eclogae Geol. Helvetiae, vol. 51, pp. 854-893.

Berthois, Leopold (1958) La formation des estuaires et des deltas: Acad. Sci., Paris, C. R. t. 247, pp. 947-950.

------- (1963) Contribution a l'etude de la sedimentation dans l'estuaire du fleuve Konkoure en periode d'etiage (Republic de Guinee): Cahiers Oceanogr., vol. 15, pp. 16-52.

------- (1966) La sedimentation, en periode de crue dans le fleuve Konkoure: Revue Geogr. Phys. Geol. Dynam., vol. 9, pp. 253-262 (English sum.).

------- and Guilcher, A. (1956) La plaine d'Ambilobe; etude morphologique et sedimentologique: Revue de Geomorphol. Dynamique, vol. 7, no. 3-4, pp. 33-52.

------- and Morize, Jean (1960) Premiere evaluation du debit solide total de la Loire: Acad. Sci., Paris, C. R. t. 251, pp. 1543-1545.

------- and Hoorelbeck, Jacques (1966) La sedimentation dans les cours d'eau et sur les cotes de la Guyane francaise: Acad. Sci., Paris, C. R. t. 263, ser. D, pp. 955-958.

Bird, E. C. F. (1962) The river deltas of the Grippsland lakes: Royal Soc. Victoria, Proc., vol. 75, pt. 1, pp. 65-74.

Bondar, C. (1968a) The Maritime stretch of the Danube River and its Sulina Mouth (trans.): Bucharest, Institutul de Studii se Cercetari Hidrotehnice, Studii de Hidrologie, no. 25, pp. 5-58 (in Rumanian, English abst.).

-------(1968b) Some aspects of water mass hydrodynamics at the mouth of the Sulina Arm (trans.): Bucharest, Institutul de Studii se Cercetari Hidrotehnice, Studii de Hidrologie, no. 25, pp. 75-94 (in Rumanian, English abst.).

-------(1968c) Hydraulic and hydrological conditions of Black Sea water penetration into the Danube River mouths (trans.): Bucharest, Institutl de Studii se Cercetari Hidrotehnice, Studii de Hidrologie, no. 25, pp. 103-122 (in Rumanian, English abst.).

------- and Mihailescu, P. (1968) Grain-size composition of the sediment layer in the area of the mouth of the Sulina arm (trans.): Bucharest, Institutl de Studii se Cercetari Hidrotechnice, Studii de Hidrologie, no. 25, pp. 127-142 (in Rumanian, English abst.).

------- and State, I. (1968) Flow velocity and bedload transportation at the mouth of the Sulina arm (trans.): Bucharest, Institutul de Studii se Cercetari Hidrotehnice, Studii de Hidrologie, no. 25, pp. 165-175 (in Rumanian, English abst.).

Bonham-Carter, G. F. and Sutherland, A. J. (1967) Diffusion and settling of sediments at river mouths: Gulf Coast Assoc. Geol. Soc. Trans., vol. 17, pp. 326-338.

Borichansky, L. S. and Mikhailov, V. N. (1966) Interaction of river and sea water in the absence of tides: in Problems of the humid tropic zone deltas and their implications: UNESCO, Proc. Dacca Sym., pp. 175-180.

Bornhauser, M. (1947) Marine sedimentary cycles of Tertiary in Mississippi Embayment and Central Gulf Coast Area: Bull. Amer. Assoc. Petrol. Geol., vol. 31, pp. 696-712.

Botvinkina, L. N. (1963) Some specific features in the genetic types of deposits and law governing their stratification in paralic formations of various climatic areas: Akad. Nauk SSSR Geol. Inst. Trudy, vol. 81, pp. 332-373.

-------, Feofilova, A. P. and Jablokov, V. C. (1954) A study of textures and conditions of deposition of Recent alluvium and certain deposits in the lower reaches of the Don River and shore of the Azov Sea (trans.) in Alluvial deposits in the coal measures of the Middle Carboniferous of the Donets Basin: Akad. Nauk SSSR, Inst. Geol., Ser. Geol., Trudy, vol. 15, pp. 30-89 (in Russian).

------- and Yablokov, V. S. (1964) Specific features of deltaic deposits in coal-bearing and cupriferous formations in Developments in sedimentology, vol. 1, Deltaic and shallow marine deposits: Elsevier Pub. Col, Amsterdam, pp. 39-47.

-------, et al. (1956) Atlas of lithogenetic types of Middle Carboniferous coal measures of the Donetz Basin: Akad. Nauk SSSR, Moscow, 368 pp.

Boyd, D. R., and Dyer, B. F. (1964) Frio Barrier Bar System of South Texas: Gulf Coast Assoc. Geol. Socs. Trans., vol. 14, pp. 309-322.

Brand, E., and Hoffman, K. (1963) Stratigraphy and facies of the Northwest German Jurassic and genesis of its oil deposits: 6th World Petrol. Cong., Sed. I, Pap. 17, Germany, pp. 1-23.

Brauer, Joachim, and Buntfuss, Jurgen (1967) Sedimentologische untersuchungen in oberen Wesfal C and unteren Westfal D des Ibbenburenerkarbons in Zur Geologie des nordwestdeutschen Steinkohlengebirges: ein Symposium: Fortschr. Geol. Rheinland Westfalen, vol. 13, pt. 2, pp. 1095-1108 (in German; French and English sum.).

Briggs, Garrett (1968) Sedimentation in Breton Sound and effects of the Mississippi River-Gulf outlet: Gulf Coast Assoc. Geol. Socs. Trans., vol. 18, pp. 304-319.

Bromgersma-Sanders, M. (1948) The importance of upwelling water to vertebrate paleontology and oil geology: K. Nederlansche Akad. Wetensch. Amsterdam Verh., Akad. Natwurk., Sec. 2, vol. 45, no. 4, pp. 1-112.

Bronfman, A. M. (1962) The compensatory flow of seawater during wind-generated movement of water offshore in coastal shallows in front of a river: Oceanology, vol. 2, no. 4 (English trans.).

------- (1966) Magnitude of suspended sediment discharge in the Don River (trans.): Rostov-on-the-Don, Gidrometeorologicheskaia Observatoriia, Sbornik Rabot, vol. 4 (in Russian).

------- and Aleksandov, A. N. (1965) The Don estuary as an example of sedimentation in marine shallows in front of an estuary: Oceanology, vol. 5, no. 4, pp. 68-75 (English trans.).

Brosge, W. P. and Whittington, C. L. (1966) Geology of the Umiat-Maybe Creek region, Alaska: U. S. Geol. Survey Prof. Paper 303-H, pp. 501-638.

Brouwer, A. (1953) Rhythmic depositional features of the East Surinam coastal plain: Geol. en Mijnbouw, n. s., vol. 15, pp. 226-236.

------- (1963) Cainozoic history of the Netherlands: Geol. en Mijnbouw, vol. 21, pp. 117-148.

Brown, L. F., Jr. (1968) Shelf model for Late Pennsylvanian and Early Permian deposition in north-central Texas (abst.): Geol. Soc. Amer. Ann. Mtg., South-central Sec., Program, pp. 12-13.

------(1969a) Late Pennsylvanian paralic sediments in Guidebook to the Late Pennsylvanian Shelf sediments, North-central Texas: Dallas, Tex., Dallas Geol. Soc., April, 1969, pp. 21-33.

------(1969b) Virgil and Lower Wolfcamp repetitive environments and the depositional model, North-central Texas in Symposium on cyclic sedimentation in the Permian Basin: West Texas Geol. Soc., pp. 115-134.

------(1969c) Geometry and distribution of fluvial and deltaic sandstones (Pennsylvanian and Permian), North-central Texas: Gulf Coast Assoc. Geol. Socs. Trans., vol. XIX.

------- (1971) Virgil and Wolfcamp fluvial, deltaic, and interdeltaic embayment depositional systems in north and west-central Texas (abst.): Bull. Amer. Assoc. Petrol. Geol., vol. 55, pp. 151-152.

------- and Galloway, W. E. (1971) Recognition of fluvial and deltaic sandstones of Pennsylvanian and Permian ages in north-central Texas (abst.): Bull. Amer. Assoc. Petrol. Geol., vol. 55, p. 332.

Brown, S. L. (1967) Stratigraphy and depositional environment of the Elgin Sandstone (Pennsylvanian) in South-central Kansas: Kansas Geol. Survey Bull. 187, pt. 3, 9 p.

Burnes, A. (1832) Comparison of the Indus and Ganges rivers: Asiatic Soc. Bengal Jour., vol. 1, pp. 145-148.

Burst, J. F. (1969) Diagenesis of Gulf Coast clayey sediments and its possible relation to petroleum migration: Bull. Amer. Assoc. Petrol. Geol., vol. 53, pp. 73-93.

Busch, D. A. (1953) The significance of deltas in subsurface exploration: Tulsa Geol. Soc. Digest, vol. 21, pp. 71-80.

------- (1959) Prospecting for stratigraphic traps: Bull. Amer. Assoc. Petrol. Geol., vol. 43, pp. 2829-2843.

Butzer, K. W. (1970) Contemporary depositional environments of the Omo Delta: Nature, vol. 226, pp. 425-430.

Canali, L. (1959) Inagine sulla ripartizione della portata del Po tra i vari rami del delta e sulla loro attivita di de flusso: Gior. Genio Civile, vol. 97, no. 12, 19 pp.

------- (1963) Transport of suspended sediments in the Po Delta (trans.): Cong. on Hydraulics, 8th, Pisa, pp. 1-13 (in Italian).

Carless, T. F. (1838) Memoir to accompany the survey of the delta of the Indus: Jour. Royal Geogr. Soc., vol. 8, pp. 328-366.

Cavaroc, V. V., Jr. (1969) Delineation of some outer deltaic plain subenvironments based on sedimentary properties in vertical section (abst.): Bull. Amer. Assoc. Petrol. Geol., vol. 53, pp. 710-711.

------- (1969) Geology of some Carboniferous deltaic plain sediments of western Pennsylvanian: Dissertation, Louisiana State Univ., Baton Rouge, 200 pp.

------- and Ferm, J. C. (1968) Siliceous spiculites as shoreline indicators in deltaic sequences: Bull. Geol. Soc. Amer., vol. 79, pp. 263-272.

Chadwick, G. H. (1933) Great Catskill delta and revision of late Devonic succession (Upper Devonian revision in New York and Pennsylvania): Pan-Am. Geologist, vol. 60, pp. 91-107, 189-204, 275-286, 348-360.

Chang, H. Y., Simons, D. B., and Brooks, R. H. (1967) The effect of water detention structures on river and delta morphology in Symposium on river morphology: Assoc. Internat. Hydrol. Scientifique, Bern, no. 75, pp. 438-448.

Chatley, Herbert (1940) The hydrology of the Yangtze River: Inst. Civil Engr. Jour., vol. 14, pp. 227-234.

Chebykin, A. A. (1929) Accretion of the Don Delta and formation of the baymouth bar: All-Union Hydrological Cong., 2nd, Proc., pt. 2 (in Russian).

Chowdhury, M. I. (1966) On the gradual shifting of the Ganges from west to east in delta-building operations in Scientific problems of the humid tropical zone deltas and their implications: UNESCO, Proc. Dacca Symposium, pp. 35-40.

Ciabatti, Mario (1968) Ricerche sull'evoluzione del delta padano: Gior. Geol., Bologna Museo Geologico, vol. 34, pp. 381-406 (English sum.).

------- and Colantoni, P. G. (1967) Ricerche sui fondali antistanti il delta del Po: Gior. Geol., Bologna Museo Geologico, vol. 34, pp. 189-210 (English sum.).

Clapp, F. G. (1922) The Hwang Ho, Yellow River: Geog. Review, vol. 12, pp. 1-18.

Coleman, J. M. (1962) Recent peat deposits of Vermilion, Iberia, and St. Mary Parishes, Louisiana *in* Natl. Coastal and Shallow Water Research Conf., 1st, Proc.: [Washington, D. C.] Natl. Sci. Found. and [U.S.] Office Naval Research, pp. 467-468.

------- (1967) Deltaic evolution *in* Fairbridge (ed.), Encyclopedia of earth sciences: Reinhold, New York, pp. 255-261.

-------, *et al.* (1964) Minor sedimentary structures in a prograding distributary: Marine Geology, vol. 1, pp. 240-258.

-------, *et al.* (1965) Geomorphology of a high-tide tropical delta--the Burdekin River, Queensland, Australia (abst.): Program, 1965 Ann. Mtg., Geol. Soc. Amer., p. 85.

-------, *et al.* (1970) Sedimentation in a Malaysian high tide tropical delta: Soc. Econ. Pal. Min. Spec. Pub. 15, pp. 185-197.

-------, Ferm, J. C. and Gagliano, S. M. (1969) Recent and ancient deltaic sediments; a comparison: Coastal Studies Inst., Louisiana State Univ., Baton Rouge, 205 pp.

------- and Gagliano, S. M. (1964) Cyclic sedimentation in the Mississippi River deltaic plain: Gulf Coast Assoc. Geol. Socs. Trans., vol. 14, pp. 67-80.

------- and ------- (1965) Sedimentary structures--Mississippi River deltaic plain *in* Primary sedimentary structures and their hydrodynamic interpretation--A symposium: Soc. Econ. Pal. Min. Spec. Pub. 12, pp. 133-148.

-------, ------- and Morgan, J. P. (1969) Mississippi River subdeltas: Natural models for deltaic sedimentation: Louisiana State Univ., Coastal Studies Bull. 3, pp. 23-27.

-------, ------- and Smith, W. G. (1970) Geomorphology of a high-tide tropical delta--The Burdekin River, Queensland, Australia (abst.): Geol. Soc. Amer. Ann. Mtg., Program, p. 35.

------- and Smith, W. G. (1964) Studies of Quaternary sea level: Louisiana State Univ., Coastal Studies Inst. Tech. Rept. 20, pp. 833-840.

Collins, F. R. (1958) Test wells, Topagoruk area, Alaska: U. S. Geol. Survey Prof. Paper 305-D, pp. 265-316.

Collinson, J. D. (1968) Deltaic sedimentation units in the Upper Carboniferous of northern England: Sedimentology, vol. 10, pp. 233-254.

------- (1969) The sedimentology of the Grindslow Shales and the Kinderscout Grit: a deltaic complex in the Namurian of northern England: Jour. Sed. Petrology, vol. 39, pp. 194-221.

Cooray, P. G. (1968) The geomorphology of part of the north-western coastal plain of Ceylon: Z. Geomorphol., vol. 7, pp. 95-113.

Corpus Christi Geological Society (1962) Sedimentology of South Texas--Annual field trip, June 1962: Corpus Christi (Tex.) Geological Society, guidebook, 82 pp.

Corthell, E. L. (1884) The south pass jetties--ten years' practical teachings in river and harbor hydraulics: Amer. Soc. Civil Engrs. Trans., vol. 13, pp. 313-330.

Credner, G. R. (1878) Die Deltas, ihre morphologe, geographische, verbreitung und entstehungs-bedingungen, in Petermann's "Geographischen Mittheilungen" Erganzungsheft No. 56, 74 pp.

Crickmay, C. H. (1955) Delta formation: Bull. Amer. Assoc. Petrol. Geol., vol. 39, pp. 107-114.

Curray, J. R. (1969) Estuaries, lagoons, tidal flats, and deltas, in The new concepts of continental margin sedimentation, application to the geological record: Philadelphia, Amer. Geol. Inst., Short Course Lecture Notes, pp. JCIII 1-JCIII 30.

------- and Moore, D. G. (1964) Pleistocene deltaic progradation of continental terrace, Costa de Nayarit, Mexico, in Marine geology of the Gulf of California--A symposium: Amer. Assoc. Petrol. Geol., Mem. 3, pp. 193-215.

Curtis, D. M. (1970) Miocene deltaic sedimentation, Louisiana Gulf Coast, in Deltaic sedimentation, modern and ancient: Soc. Econ. Pal. Min. Spec. Pub. 15, pp. 293-308.

Dahlskog, Sten (1966) Sedimentation and vegetation in a Lapland mountain delta: Geogr. Ann. Stockholm, Ser. A., vol. 48, pp. 86-101 (in Swedish).

D'Arrigo, A. (1963) The systematization of types of river mouths, particularly regarding the Po Delta (trans.): Rivista Ingegneria (Milan), no. 11, pp. 1242-1246 (in Italian).

Davies, D. K. and Moore, W. R. (1970) Dispersal of Mississippi sediment in the Gulf of Mexico: Jour. Sed. Petrology, vol. 40, pp. 339-353.

de Jong, J. D. (1960) The morphological evolution of the Dutch coast: Geol. en Mijnbouw, vol. 39, pp. 638-643.

-------, Hageman, B. P. and van Rummelen, F.F.F.E. (1960) De holocene afzettingen van het delta-gebied: Geol. en Mijnbouw, vol. 39, pp. 654-660 (in Dutch).

De Raaf, M. F. M., et al. (1965) Cyclic sedimentation in the Lower Westphalian of north Devon, England: Sedimentology, vol. 4, pp. 1-52.

Diaconu, C. Stanescu, V., and Bondar C. (1966) Experience in the hydrologic study of the Danube Delta (trans.): Bucharest Institutul de Studii se Cercetari Hidrotehnice, Studii de Hidrologie, no. 18, pp. 137-169 (in Rumanian, English abst.).

Dickinson, George (1953) Geological aspects of abnormal reservoir pressures in Gulf Coast Louisiana: Bull. Amer. Assoc. Petrol.Geol., vol. 37, pp. 410-432.

Dillard, W. R. (1941) Olympic Pool, Hughes and Okfuskee counties, Oklahoma, in Stratigraphic type oil fields: Tulsa, Okla., Amer. Assoc. Petrol. Geol., pp. 456-472.

Dobby, E. H. G. (1936) The Ebro Delta: Geogr. Jour., London, vol. 87, pp. 455-469.

------- (1951) Kelantan Delta, Geog. Review, vol. 41, pp. 226-255.

Dohm, C. F. (1936) Petrography of two Mississippi River subdeltas: Louisiana Dept. Conservation, Geol. Bull. 8, pp. 339-396.

Donaldson, A. C. (1966) Deltaic sands and sandstones, in Symposium on recently developed geologic principles and sedimentation of the Permo-Pennsylvanian of the Rocky Mountains: Wyoming Geol. Assoc., 20th Ann. Field Conf., Guidebook, pp. 31-62.

------- (1969) Ancient deltaic sedimentation (Pennsylvanian) and its control on the distribution, thickness, and quality of coals, in Some Appalachian coals and carbonates; models of ancient shallow-water deposition: West Virginia Geol. Econ. Survey, pp. 93-105.

-------, Martin, R. H. and Kanes, W. H. (1970) Holocene Guadalupe Delta of the Texas Gulf Coast, in Deltaic sedimentation, modern and ancient: Soc. Econ. Pal. and Min. Spec. Pub. 15, pp. 107-137.

Dondanville, R. F. (1963) The Fall River Formation, northwestern Black Hills--Lithology and geologic history, in Northern Powder River basin, Wyoming and Montana--1st Joint Field Conf., 1963, Guidebook: Billings, Mont., Billings Geol. Soc., pp. 87-99.

Dooge, Jasper (1967) The stratigraphy of an Upper Devonian carbonate-shale transition between the North and South Rivers of the Canadian Rocky Mountains: Leidse Geol. Meded., vol. 39, pp. 1.-53.

Dott, R. H., Jr. (1964) Ancient deltaic sedimentation in eugeosynclinal belts, in Developments in sedimentology, vol. 1, Deltaic and shallow marine deposits: Internat. Sedimentological Cong., 6th Amsterdam and Antwerp, 1963, Proc., pp. 105-113.

------- (1966) Eocene deltaic sedimentation at Coos Bay, Oregon: Jour. Geology, vol. 74, pp. 373-420.

Duboul-Razavet, Christiane (1951) Delta du Rhone promontoire deltaique du grand Rhone: Internat. Cong. Sedimentology, 3rd, Netherlands, Proc., pp. 99-108.

------- (1956) Contribution a l'etude geologique et sedimentologique de delta du Rhone: Soc. Geol. France, Mem. 76, vol. 35, no. 3, 234 pp.

------- and Kruit, Cornelius (1957) Sedimentologie du delta du Rhone: Inst. Franc. Petrole., Rev., vol. 12, pp. 399-410.

Duff, P. McL. D. (1967) Cyclic sedimentation in the Permian coal measures of New South Wales: Jour. Geol. Soc. Australia, vol. 14, pt. 2, pp. 293-307.

-------, et al. (1967) Cyclic sedimentation, in Transitional regimes, chapters 4 and 5 of Developments in Sedimentology 10: Elsevier Publ. Co., Amsterdam, pp. 81-156.

------- and Walton, E. K. (1962) Statistical basis for cyclothems: a quantitative study of the sedimentary succession in the East Pennine Coalfield: Sedimentology, vol. 1, pp. 235-255.

Dunham, K. C. (1950) Lower Carboniferous sedimentation in the Northern Pennines (England): Internat. Geol. Cong., 18th, vol. 4, pp. 43-63.

Edelman, C. H. (1956) Sedimentology of the Rhine and Meuse deltas as an example of the sedimentology of the Carboniferous: Geol. en Mijnbouw, Geol. Ser. 16, pp. 64-75.

Egorov, E. N. and Kas'yanov, B. L. (1961) Intense recent modifications of a seacoast brought about by the advance of a river delta and the construction of breakwaters (trans.): Akad. Nauk SSSR, Institut Ikeanologii, Trudy, vol. 53 (in Russian).

Egorov, V. V. (1951) Histoire de la formation des proprietes naturelles et perspective de mise en valeur economique du delta de la Koura: Problemes de Geogr. Phy., vol. 17 (in Russian).

------- (1955) General features of the formation of coasts and deltaic plains (trans.): Akad. Nauk SSSR, Izvestiya, Ser. Geogr., vol. 4 (in Russian).

------- (1966) Main structural features of the great deltas in the territory of the U.S.S.R., in Scientific problems of the humid tropical zone deltas and their implications: UNESCO, Proc. Dacca Symposium, pp. 393-397.

Einsele, G. (1967) Sedimentary processes and physical properties of cores from the Red Sea, Gulf of Aden and off the Nile Delta: Internat. Marine Geotech. Research Conf. Proc., pp. 154-169.

Elliot, R. E. (1969) Deltaic processes and episodes; the interpretation of productive coal measures occurring in the east Midlands, Great Britain: Mercian Geol., vol. 3, pp. 111-135.

Ellis, T. G. (1873) The cause of the formation of bars at the mouths of rivers as shown in an examination of the Connecticut River: Amer. Soc. Civil Engrs. Trans., vol. 2, pp. 313-322.

Feofilova, A. P. (1959) Facies environments of lower Carboniferous coal measures accumulation in the Donetz Basin: USSR Acad. Sci. Bull. (Geol. Ser.) [English translation published by Amer. Geol. Inst., pp. 28-29]

Fergusson, J. (1863) Delta of the Ganges: Quart. Jour. Geol. Soc. London, vol. 19, pp. 321-354.

Ferm, J. C. (1962) Petrology of some Pennsylvanian sedimentary rocks: Jour. Sed. Petrology, vol. 32, pp. 104-123.

------- (1970) Allegheny deltaic deposits: Soc. Econ. Pal. Min. Spec. Pub. 15, pp. 246-255.

------- and Cavaroc, V. V., Jr. (1968) A nonmarine sedimentary model for the Allegheny rocks of West Virginia: Geol. Soc. Amer. Spec. Paper 106, pp. 1-19.

------- and ------- (1969) A field guide to Allegheny deltaic deposits in upper Ohio valley: Ohio Geol. Soc. and Pittsburgh Geol. Soc., 21 pp.

------- and Ehrlich, R. (1967) A field guide to Carboniferous detrital rocks in northern Alabama: Denver, Colo., Geol. Soc. Amer., Guide to 1967 field trip, Coal Div., pp. 11-15.

-------, Horne, J. C., Swinchatt, J. P. and Whaley, P. W. (1971) Carboniferous depositional environments in northeastern Kentucky: Kentucky Geol. Soc., Annual Field Trip Guidebook, April 23, 24, 1971, 30 pp.

------- and Williams, E. G. (1963) Model for cyclic sedimentation in the Appalachian Pennsylvanian (abs.): Bull. Amer. Assoc. Petrol. Geol., vol. 49, pp. 356-357.

Fisher, W. L. (1968) Basic delta systems in the Eocene of the Gulf Coast Basin(abst.) Gulf Coast Assoc. Geol. Socs. Trans., vol. 18, p. 48.

------- (1968) Variation in lignites of fluvial, deltaic, and lagoonal systems, Wilcox Group (Eocene) Texas: Geol. Soc. Amer., Ann. Mtg., Program with Abs., Mexico, D. F., p. 250.

------- (1969) Facies characterization of Gulf Coast Basin delta systems, with Holocene analogues: Gulf Coast Assoc. Geol. Socs. Trans., vol. 19, pp. 239-261.

------- (1971) Tertiary depositional systems, Gulf of Mexico (abst.): Bull. Amer. Assoc. Petrol. Geol., vol. 55, pp. 152-153.

------- and McGowen, J. H. (1967) Depositional systems in the Wilcox Group of Texas and their relationship to occurrence of oil and gas: Gulf Coast Assoc. Geol. Socs. Trans., vol. 17, pp. 105-125.

------- and ------- (1969) Depositional systems in the Wilcox Group (Eocene) of Texas and their relationship to occurrence of oil and gas: Bull. Amer. Assoc. Petrol. Geol., vol. 53, pp. 30-54.

-------, Brown, L. F., Jr., Scott, A. J. and McGowen, J. H. (1969) Delta systems in the exploration for oil and gas: a research colloquium: Univ. Texas, Bur. Econ. Geology.

-------, Galloway, W. E., Proctor, C. V., Jr. and Nagle, J. S. (1970) Depositional systems in the Jackson Group of Texas: Gulf Coast Assoc. Geol. Socs. Trans., vol. 20, pp. 234-261.

-------, McGowen, J. H., Brown, L. F., Jr. and Groat, C. G. (1972) Environmental Geologic Atlas of the Texas Coastal Zone: Galveston-Houston Area: Univ. Texas, Bur. Econ. Geology, 91 pp., 9 maps.

Fisk, H. N. (1944) Geological investigation of the alluvial valley of the lower Mississippi River: Mississippi River Comm., Vicksburg, 78 pp.

------- (1951) Mississippi River Valley geology, relation to river regime: Amer. Soc. Civil Engrs. Proc., vol. 77, separate no. 80, 16 pp., also, (1952) Amer. Soc. Civil Engrs. Trans., vol. 117, pp. 667-689.

------- (1952) Geological investigations of the Atchafalaya Basin and the problem of Mississippi River diversion; Vol 1: U. S. Army Corps of Engineers Waterways Expt. Sta., Vicksburg, Miss., 145 pp.

------- (1955) Sand facies of Recent Mississippi Delta deposits: World Petroleum Cong., 4th, Rome, Proc. sec. 1, pp. 377-398.

------- (1960) Recent Mississippi River sedimentation and peat accumulation: Cong. Av. Etudes de Stratigraphie et de Geologie du Carbonifere, 4th, Sept. 15-20, 1958, Heerlen, Compte rendu, pp. 187-199, Maastricht, Netherlands.

------- (1961) Bar-finger sands of the Mississippi delta, in Geometry of sandstone bodies--A symposium: Tulsa, Okla., Amer. Assoc. Petrol. Geol., pp. 29-52.

-------, et al. (1954) Sedimentary framework of the modern Mississippi delta: Jour. Sed. Petrology, vol. 24, pp. 76-99.

------- and McFarlan, E., Jr. (1955) Late Quaternary deltaic deposits of the Mississippi River--local sedimentation and basin tectonics, in Poldevaart, A., ed., Crust of the earth--a symposium: Geol. Soc. Amer. Spec. Paper 62, pp. 279-302.

Flores, R. M. (1965) Genetic types of some sandstones in the Allegheny Formation of Ohio (abs.): Bull. Amer. Assoc. Petrol. Geol., vol. 49, p. 340.

------- (1966) Middle Allegheny paleogeography in eastern Ohio: University Microfilms, Inc., Ann Arbor, Michigan, 135 pp.

------- and Ferm, J. C. (1970) A Recent model for Pennsylvanian deposition in the Marathon basin, West Texas: Jour. Sed. Petrology, vol. 40, pp. 621-628.

Fontaine, Edward (1870) Contributions to the physical geography of the Mississippi River and its delta: Amer. Geogr. Soc. Jour., vol. 3, pp. 343-378.

Forshey, C. G. (1878) Physics of the lower Mississippi River: Amer. Assoc. Adv. Sci., Proc., vol. 26, pp. 148-172.

Fosberg, F. R. (1966) Vegetation as a geological agent in tropical deltas, in Scientific problems of the humic tropical zone deltas and their implications: UNESCO, Proc. Dacca Symposium, pp. 227-233.

Fowler, L. C. (1957) Determination of location and rate of growth of delta formations: U. S. Army Corps Engrs., Omaha, M.R.D., Sediment, Memoir 6, 13 pp.

Frakes, L. A. (1965) Landslide facies and the paleoslope in the Catskill delta (abs.): Bull. Amer. Assoc. Petrol. Geol. , vol. 49, pp. 340-341.

Fraser, J. K. (1956) Physiographic notes on features in the Mackenzie Delta area: Canadian Geogr. no. 8, pp. 18-23.

Frazier, D. E. (1967) Recent deltaic deposits of the Mississippi River; their development and chronology: Gulf Coast Assoc. Geol. Socs. Trans., vol. 17, pp. 287-315.

------- and Osanik, Alex (in press) Recent peat deposits--Louisiana Coastal Plain: Geol. Soc. Amer. Spec. Paper 114.

Friedman, G. M. and Johnson, K. G. (1966) The Devonian Catskill deltaic complex of New York, type example of a "tectonic delta complex," in Deltas in their geologic framework: Houston (Tx.) Geol. Soc., pp. 171-188.

Friedman, S. A. (1960) Channel-fill sandstones in the Middle Pennsylvanian rocks of Indiana: Indiana Geol. Survey, Rept. Prog. No. 23, 59 pp.

Gagliano, S. M. (1971) Building new marshes and estuaries in coastal Louisiana through controlled sedimentation (abst.): Bull. Amer. Assoc. Petrol. Geol., vol. 55, p. 339.

------- and McIntire, W. G. (1968) Reports on the Mekong River Delta: Louisiana State Univ., Coastal Studies Inst. Tech. Rept. 57, 143 pp.

Gallais, J. (1967) Le delta interieur du Niger et ses bordures, etude geomorphologiques: Mem. et Doc. Centre Doc. Cartogr. C.N.R.S., Paris, NS 3, 155 pp.

Galloway, W. E. (1968) Depositional systems of the Lower Wilcox Group, North-central Gulf Coast Basin: Gulf Coast Assoc. Geol. Socs. Trans., vol. 18, pp. 275-289.

------- (1971) Facies of Cisco-equivalent slope depositional systems and their role in construction of eastern shelf (abst.): Bull. Amer. Assoc. Petrol. Geol., vol. 55, p. 153.

------- and Brown, L. F., Jr. (1972) Depositional systems and shelf-slope relationships in Upper Pennsylvanian Rocks, North-central Texas: Univ. Texas, Bur. Econ. Geology Rept. Inv. 75, 63 pp.

Gama, Ercilio, Jr. (1970) Arcabouco Estratigrafico das Bacias do Reconcavo e Tucano: Internal Rept., Petroleo Brasileiro S. A., RPBA-DIREX no. 1271, 18 pp.

Ganser, R. W. (1967) Recent delta growth in the Butcher Pen, Lake Texoma, Oklahoma: Oklahoma Geol. Notes, vol. 27, pp. 232-233.

Garrison, R. E., et al. (1969) Early diagenetic cementation of recent sands, Fraser River delta, British Columbia: Sedimentology, vol. 12, pp. 27-46.

Gellert, J. F. (1968) The Yangtse River mouth and delta (trans.): Warsaw, Przeglad Geogr., vol. 40, pp. 413-418 (in German).

Ghignone, J. I. (1970) A sedimentacao Ilhas Inferior: Internal Rept. Petroleo Brasileiro S. A., RPBA-DIREX no. 1317, 44 pp.

Gierloff-Emden, H. G. (1959) Die Kuste von El Salvador; Eine morphologisch-ozeanographische Monographie: Acta Humboldtiana, ser. geogr. et ethn., NR 2, 183 pp.

Gilbert, G. K. (1882) Contributions to the history of Lake Bonneville: U. S. Geol. Survey 2nd Ann. Rept., pp. 167-200.

------- (1885) The topographic features of lake shores: U. S. Geol. Survey Ann. Rept. 5, pp. 104-108.

Giresse, Pierre (1969) Carte sedimentologique des fonds sousmarins du delta de l'Ogoove: Cahiers Oceanogr., vol. 21, pp. 965-994.

------- (1970) Les limites de la province sedimentaire littorale du delta du Llobregat: Cahiers Oceanogr., vol. 22, pp. 581-612.

Gistescu, Petre and Stancescu, Cornellia (1964) Some considerations on the Danube Delta lakes (trans.): Bucharest Institutul de Studii se Cercetari de Geologie, Geofizica, Geografie, Geogr. Ser. no. 11, pp. 53-62 (in Rumanian).

Glaister, R. P. (1959) Lower Cretaceous of southern Alberta and adjoining areas: Bull. Amer. Assoc. Petrol. Geol., vol. 43, pp. 590-640.

Gole, C. V. and Chitale, S. V. (1966) Inland delta building activity of Kosi River: Jour. Hydraulics Div., Proc. Amer. Soc. Civil Engrs., vol. 92, Hy2, pp. 111-126.

Goodell, H. G. (1962) The stratigraphy and petrology of the Frontier Formation of Wyoming, in Symposium on Early Cretaceous rocks of Wyoming and adjacent areas--Wyoming Geol. Assoc., 17th Field Conf., 1962: Casper, Wyo., Petroleum Inf., pp. 173-210.

Goodlet, G. A. (1959) Mid-Carboniferous sedimentation in the Midland Valley of Scotland: Edinburgh (Scotland) Geol. Soc. Trans., vol. 17, pp. 217-240.

Gordon, Robert (1882) The Irrawaddy and the Sanpo: Royal Geogr. Soc. Proc. (London), vol. 4, pp. 559-563.

------- (1885) The Irrawaddy River: Proc. Royal Geograph. Soc., new ser., vol. 7, pp. 292-331.

Goremykin, V. Y. (1967) Volga-delta marginal accretion at Volgograd in 1959-1964 (trans.): Astrakhan Kaspiiskii nauchnoissledovatel' skii Institut Rybnogo Khoziaistva, Trudy, vol. 23, pp. 19-24 (in Russian).

Gorsline, D. S. (1967) Sedimentologic studies of the Colorado Delta: Univ. Southern California, Geol. Rept. 67-1, 121 pp.

Gould, H. R. (1965) The Mississippi Delta complex (abs.): Bull. Amer. Assoc. Petrol. Geol., vol. 49, p. 342.

------- (1970) The Mississippi Delta Complex: Soc. Econ. Pal. Min. Spec. Pub. 15, pp. 3-30.

------- and Morgan, J. P. (1965) Coastal Louisiana swamps and marshlands: Internat. Assoc. Quaternary Research, 7th Cong., Proc., pp. 30-72.

Greensmith, J. T. (1962) Rhythmic deposition in the Carboniferous Oil-Shale Group of Scotland: Jour. Geology, vol. 70, pp. 355-364.

------- (1965) Calciferous Sandstone Series sedimentation at the eastern end of the Midland Valley of Scotland: Jour. Sed. Petrology, vol. 35, pp. 223-242.

------- (1966) Carboniferous deltaic sedimentation in eastern Scotland: A review and reappraisal, in Deltas in their geologic framework: Houston (Tx.) Geol. Soc., pp. 189-211.

Gregory, J. L. (1966) A lower Oligocene delta in the subsurface of southeastern Texas: Gulf Coast Assoc. Geol. Socs. Trans., vol. 16, pp. 227-241.

Griffin, G. M., and Parrott, B. S. (1964) Development of clay mineral zones during deltaic migration: Bull. Amer. Assoc. Petrol. Geol., vol. 48, pp. 57-69.

Grumazescu, H. (1963) Physical-geographical processes taking place at present in the area of the Danube Delta (trans.): Hidrobiologia, Bucharest, vol. 4, pp. 83-106 (in Rumanian).

-------, et al. (1963) Physical-geographical units of the Danube Delta (trans.): Hidrobiologia, Bucharest, vol. 4, pp. 129-162 (in Rumanian).

Gulliver, F. P. (1899) Shoreline topography: Proc. Amer. Acad. Arts Sci., vol. 34, pp. 151-258.

Hails, J. R., and Hoyt, J. H. (1968) Barrier development on submerged coasts: Problems of sea-level changes from a study of the Atlantic Coastal Plain of Georgia, U.S.A. and parts of the Eastern Australian coast: Z. Geomorphol., vol. 7, pp. 24-55.

Hale, L. A. (1961) Late Cretaceous (Montanan) stratigraphy, eastern Washakie Basin, Carbon County, Wyoming, in Symposium on Late Cretaceous rocks, Wyoming and adjacent areas, Wyoming Geol. Assoc., 16th Ann. Field Conf., 1961: Casper Wyo., Petroleum Inf., pp. 129-137.

------- (1962) Frontier Formation--Coalville, Utah, and nearby areas of Wyoming and Colorado, in Symposium on Early Cretaceous rocks of Wyoming and adjacent areas--Wyoming Geol. Assoc., 17th Ann. Field Conf., 1962: Casper, Wyo., Petroleum Inf., pp. 211-220.

-------, and van de Graaff, F. R. (1964) Cretaceous stratigraphy and facies patterns--Northeastern Utah and adjacent areas, in Guidebook to the geology and mineral resources of the Uinta Basin, Utah's hydrocarbon storehouse, 13th Ann. Field Conf., 1964: Salt Lake City, Intermountain Assoc. Petroleum Geologists, pp. 115-138.

Hansen, H. J. (1969) Depositional environments of subsurface Potomac Group in southern Maryland: Bull. Amer. Assoc. Petrol. Geol., vol. 53, pp. 1923-1937.

Hatley, C. A. (1873) On the delta of the Danube and the provisional works executed at the Sulina mouth: Inst. Civil Engr., London, Proc., vol. 26, pp. 201-253.

Hatlin, D. E. (1964) Cyclic sedimentation in the Colorado group of west-central Texas: Kansas Geol. Soc. Bull., vol. 169, pp. 205-217.

Haun, J. D. (1965) Cretaceous deltas in the Denver basin and relationship to petroleum (abs.): Bull. Amer. Assoc. Petrol. Geol., vol. 49, p. 344.

-------, and Barlow, J. A., Jr. (1962) Lower Cretaceous stratigraphy of Wyoming, in Symposium on Early Cretaceous rocks of Wyoming and adjacent areas--Wyoming Geol. Assoc., 17th Ann. Field Conf., 1962: Casper, Wyo., Petroleum Inf., pp. 15-22.

Havlena, V. J., and Pesek, J. (1968) Problems of the geology of the Upper Silesian Basin, the Boskovice Furrow, and the Plzen Basin: Internat. Geol. Congress, 23rd Sess., Czechoslovakia, Charles Univ., Prague, 64 pp.

Hedgpeth, J. W. (1951) The classification of estuarine and brackish waters and the hydrographic climate: Nat. Res. Council, Comm. on a Treatise on Marine Ecology and Paleoecology, Rept., 1950-51, pp. 46-56.

Heezen, B. C. (1965) Currientes de turbidez de Rio Magdalena: Soc. Geogr. Columbia, Bol. no. 51 and 52, pp. 135-143.

Heling, D., and Wurster, P. (1971) Deltaic sediments of the Keuper Basin in southwest Germany, pp. 133-146, in Muller, G., ed., Sedimentology of parts of Central Europe: Frankfurt, Verlag Kramer, 344 pp.

Henoch, W. E. S. (1960) Fluvio-morphological features of the Peel and lower Mackenzie rivers: Canada Dept. Mines and Tech. Surveys, Geogr. Branch, Geogr. Bull. 15, pp. 31-45.

Hervieu, J. (1966) Contribution à l'étude du milieu fluvio-marin sur la côte occidentle du Madagascar: Revue de geographie, no. 8, pp. 11-77, Tananarive.

Hilmy, M. M., and Shahat, A. (1969) Geological and mineralogical studies of some sand deposits in the Nile Delta: Jour. Sed. Petrology, vol. 39, pp. 1520-1529.

Holeman, J. N. (1968) The sediment yield of major rivers of the world: Water Resources Research, vol. 4, pp. 737-747.

Holle, C. G. (1952) Sedimentation at the mouth of the Mississippi River: Chap. 10 of Johnson, J. W., ed., Coastal engineering, Proc., 2d Conf., Nov. 1951: Berkeley, Univ. California, pp. 111-129.

Hollerwoger, F. (1965) The accelerated growth of river deltas in Java: Madjalah Geografi Indonesia, vol. 4, pp. 1-15 (English edition).

------- (1966) The progress of the river deltas in Java, in Scientific problems of the humid tropic zone deltas and their implications: UNESCO, Proc. Dacca Sym., pp. 347-355.

Hoover, J. (1967) Stratigraphy of Monongahela Group in West Virginia, Ohio and Pennsylvania: Master's Thesis, West Virginia Univ., 38 pp.

Hopkins, M. E. (1958) Geology and petrology of the Anvil Rock sandstone in southern Illinois: Illinois Geol. Survey Circ. 256, 49 pp.

Horowitz, D. H. (1966) Evidence for deltaic origin of an upper Ordovician sequence in the central Appalachians, in Deltas and their Geologic Framework, Houston Geol. Soc., pp. 159-170.

Howard, C. S. (1947) Suspended sediment in the Colorado River: U. S. Geol. Survey Water Supply Paper 998, 165 pp.

Howe, H. V., et al. (1935) Reports on the geology of Cameron and Vermilion Parishes: Louisiana Geol. Survey Bull. 6, 242 pp.

Hrabar, S. U., and Potter, P. E. (1969) Lower Baden (Mississippian) sandstone body of Owen and Green Counties, Indiana: Bull. Amer. Assoc. Petrol. Geol., pp. 2150-2160.

Hubert, J. F., Butera, J. G., and Rice, R. F. (1972) Sedimentology of Upper Cretaceous Cody-Parkman delta, southwestern Powder River Basin, Wyoming: Bull. Geol. Soc. Amer., vol. 83, pp. 1649-1670.

Humphreys, A. A., and Abbet, H. L. (1861) Report upon the physics and hydraulics of the Mississippi River: U. S. Army Topgr. Eng. Prof. Paper no. 4, 456 pp., *reprinted* 1876, Prof. Paper no. 13, 691 pp.

Ichiye, T. (1960) On the hydrography near Mississippi Delta: Oceanographical Mag., Tokyo, vol. 11, pp. 65-78.

Ionides, M. G. (1937) The regime of the rivers Euphrates and Tigris: London, Spon.

Ivanov, V. V. (1967) Bottom sediments and bottom dynamics of the Byko branch of the Lena River Delta (trans.): Leningrad Arktieheskii i Antarticheskii Nauchnoissle-dovatel'skii Institut, Trudy, vol. 278, pp. 126-141.

Jackson, W. E. (1964) Depositional topography and cyclic deposition in west-central Texas: Bull. Amer. Assoc. Petrol. Geol., vol. 48, pp. 317-328.

Jacobsen, N. K. (1960) Types of sedimentation in a drowned delta region; examples from the salt-marsh area at Tonder, *in* Contributions to problems discussed in symposia and excursions: Guidebook, Internat. Beogr. Cong., 19th, Denmark, pp. 77-89.

Jansa, L. F. (1971) Depositional history of the coal-bearing Upper Jurassic-Lower Cretaceous Kootenay Formation, Southern Rocky Mountains: Geol. Soc. Amer. field trip guidebook, May 10-12, 1971.

Johns, W. D., and Grim, R. E. (1958) Clay mineral composition of Recent sediments from Mississippi River delta: Jour. Sed. Petrology, vol. 28, pp. 186-199.

Johnson, K. G., and Friedman, G. M. (1969) The Tully clastic correlatives (Upper Devonian) of New York State: a model for recognition of alluvial, dune, tidal, nearshore (bar and lagoon) and offshore sedimentary environments in a tectonic delta complex: Jour. Sed. Petrology, vol. 39, pp. 451-485.

Johnson, W. A. (1921a) The occurrence of calcareous sandstones in the Recent delta of the Fraser River, British Columbia, Canada: Amer. Jour. Sci., 5th Ser., vol. 1, pp. 447-453.

-------(1921b) Sedimentation of the Fraser River delta: Canad. Geol. Survey Mem. 125, 46 pp.

------- (1922) The character of the stratification of the sediments in the recent delta of the Fraser River delta, British Columbia, Canada: Jour. Geology, vol. 30, pp. 115-129.

Johnston, G. H., and Brown, R. J. E. (1965) Stratigraphy of the MacKenzie River Delta, Northwest Territories, Canada: Bull. Geol. Soc. Amer., vol. 76, pp. 103-112.

Jones, D. J. (1965) The Gilbert-type delta (abs.): Bull. Amer. Assoc. Petrol. Geol., vol. 49, p. 345.

Jones, P. H. (1968) Hydrodynamics of geopressure in the northern Gulf of Mexico basin: Soc. Petrol. Engrs. of AIME, spec. preprint paper 2207, 12 pp.

Jopling, A. V. (1963) Hydraulic studies on the origin of bedding: Sedimentology, vol. 2, pp. 115-121.

------- (1964) Laboratory study of sorting processes related to flow separation: Jour. Geophys. Research, vol. 69, pp. 3403-3418.

------- (1965) Hydraulic factors controlling the shape of laminae in laboratory deltas: Jour. Sed. Petrology, vol. 35, pp. 777-791.

-------, and Walker, R. G. (1968) Morphology and origin of ripple-drift cross-lamination with examples from the Pleistocene of Massachusetts: Jour. Sed. Petrology, vol. 38, pp. 971-984.

Jux, von Ulrich (1966) Torfe des rheineschen Tertiärs im Vergleich mit heutigen Bildungen am der amerikanischen Ostkuste: Z. Deutsch. Geol. Ges., Bd. 118, pp. 69-101.

Kanes, W. H. (1965) Facies and development of the delta of the Colorado River, Texas: Ph.D. Dissertation, West Virginia Univ., 106 pp.

------- (1970) Facies and development of the Colorado River delta in Texas: Soc. Econ. Pal. Min. Spec. Pub. 15, pp. 78-106.

-------, et al. (1965) Facies and development of the Colorado River delta in Texas (abs.): Bull. Amer. Assoc. Petrol. Geol., vol. 49, p. 346.

Kasnova, N. G. (1951) Formation of the Volga Delta deposits (trans.): Moscow, Gosudarstvennyi Okeanograficheskii Institut, Trudy, vol. 18, no. 30 (in Russian).

Klein, G. deV., deMelo, U., and Favera, J. C. D. (1972) Subaqueous gravity processes on the front of Cretaceous deltas, Reconcavo Basin, Brazil: Bull. Geol. Soc. Amer., vol. 83, pp. 1469-1492.

Klenova, M. V. (ed.) (1956) Contemporary sediments of the Caspian Sea: Akad. Sci., USSR, Moscow, 303 pp. (translated into English by Amer. Geol. Inst.).

-------, et al. (1941) Thickness of the Recent deposits of the Volga River Delta: U.S.S.R., Acad. Sci., vol. 31, no. 4, pp. 355-358.

Kohler, G. (1929) Der Hwang Ho: Eine Physiogeographie: Petermanns Mitt. Erg., no. 203.

Kolb, C. R.(1962a) Distribution and engineering significance of sediments bordering the Mississippi from Donaldsonville to the Gulf: U. S. Army Corps of Engrs., Waterways Expt. Sta. Misc. Paper 3-481, 116 pp.

-------(1962b) Distribution of soils bordering the Mississippi River from Donaldsonville to Head of Passes: U. S. Army Corps Engrs., Waterways Expt. Sta. Tech. Rept. 3-601, 61 pp.

------- (1963) Sediments forming the bed and banks of the lower Mississippi River and their effect on river migration: Sedimentology, vol. 2, pp. 227-234.

------- and Kaufman, R. I. (1967) Prodelta clays of southeast Louisiana, in Marine geotechnique--Internat. Research Conf., Monticello, Ill., 1966, Proc.: Univ. Illinois Press, pp. 3-21.

------- and Saucier, R. T. (1967) Alluvial geology of the Yazoo Basin, Lower Mississippi Valley: U. S. Army Corps Engrs., Waterways Expt. Sta., Vicksburg, Miss.

------- and van Lopik, J. R. (1958) Geology of the Mississippi River deltaic plain, southeastern Louisiana: U. S. Army Corps Engrs., Waterways Expt. Sta. Tech. Rept. 3-483 and 3-484, 2 vols., Vicksburg, Miss.

------- and ------, (1966) Depositional environments of the Mississippi River deltaic plain--southeastern Louisiana; in Deltas in their geologic framework: Houston (Tx.) Geol. Soc., pp. 17-61.

Koperina, V. V. (1958) Facies and types of coal accumulation in the Donetz coal measures: Izv. Akad. Sci. SSSR, Geol. Ser. (Am. Geol. Institute), no. 1, pp. 8-17.

Kruit, Cornelius (1951) Sediments of the Rhone Delta: Mouton and Co., Granenbrage.

------- (1955) Sediments of the Rhone delta. I. Grain size and microfauna: Kon. Nederlands Geol. Mijnbouw Gen. Verhand., vol. 15, pp. 397-499.

------- (1963) Is the Rhine delta a delta?: Kon. Nederlands Geol. Mijnbouw Gen. Verhand., vol. 21, pp. 259-266.

Kuiper, Edward (1960) Sediment transport and delta formation: Amer. Soc. Civil Engrs., Hydraulics Div., Jour., vol. 86, no. HY2, pt. 1, pp. 55-68.

Kurdyukov, K. V. (1957) Fundamental problems in the study of subaerial deltas (trans.): Akad. Nauk SSSR, vol. 21, pp. 5-37 (in Russian).

Lagaaij, R. (1965) Sediments and fauna of the Rhone delta, France (abs.): Bull. Amer. Assoc. Petrol. Geol., vol. 49, p. 347.

------- and Gautier, Y. U. (1965) Bryozoa assemblages from marine sediments of the Rhone delta, France: Micropaleontology, vol. 11, pp. 39-58.

------- and Kopstein, R. P. H. (1964) Typical features of a fluviomarine offlap sequence, in Deltaic and shallow marine deposits: Elsevier Pub. Co., Amsterdam, pp. 216-226.

Lankford, R. R. (1969) Distribution and ecology of foraminifera from eastern Mississippi Delta margin: Bull. Amer. Assoc. Petrol. Geol., vol. 43, pp. 2068-2099.

------- and Shepard, F. P. (1960) Facies interpretation in Mississippi Delta borings: Jour. Geology, vol. 68, pp. 408-426.

Laury, R. L. (1968) Sedimentology of the Pleasantview Sandstone, southern Iowa and western Illinois: Jour. Sed. Petrology, vol. 38, pp. 568-599.

Lee, Wallace (1938) Stratigraphy of the Cisco Group of the Brazos Basin, in Stratigraphic and paleontologic studies of the Pennsylvanian and Permian rocks in North-central Texas: Univ Texas Pub. 3801, pp. 11-90.

Lindeman, J. (1953) The vegetation of the coastal region of Suriname, in Vegetation of Suriname, vol. 1, pt. I, Kemink en Zoon N. V., x, 135 pp., Utrech.

Lipsey, T. E. L. (1919) Currents at and near mouth Southwest Pass, Mississippi River: U. S. Army Corps Engrs. Prof. Mem. 11, pp. 65-122.

Liteanu, E. and Pricajan, A. (1963) The geological structure of the Danube Delta (trans.): Hidrobiologia, Bucharest, vol. 4, pp. 57-82 (in Rumanian).

Lohse, E. A. (1952) Shallow-marine sediments of the Rio Grande delta: Ph. D. Dissertation, Univ of Texas, 113 pp.

------- (1962) Mouth of the Rio Grande, in Sedimentology of South Texas, Corpus Christi Geol. Soc., Ann. Field Trip, 1962: Corpus Christi (Tx.) Geol. Soc., pp. 41-42.

Lowman, S. W. (1949) Sedimentary facies of the Gulf Coast: Bull. Amer. Assoc. Petrol. Geol., vol. 33, pp. 1939-1997.

Mackay, J. R. (1963) The Mackenzie Delta area, N. W. T.: Ottawa, Canada Geol. Survey, Geog. Branch, Mem. 8, 202 pp.

MacKenzie, D. B. (1965) Depositional environments of muddy sandstone, western Denver Basin, Colorado: Bull. Amer. Assoc. Petrol. Geol., vol. 49, no. 2, pp. 186-206.

Mandelbaum, H. (1970) Definition and properties of a variability index of deltaic sediments: Jour. Sed. Petrology, vol. 40, pp. 436-445.

Manka, L. L. (1970) A study of the sediments and depositional history of a portion of the delta of the Colorado River, Texas: Texas Christian Univ., Master's Thesis, 87 pp.

Mann, C. J. and Thomas, W. A. (1968) The ancient Mississippi River: Gulf Coast Assoc. Geol. Socs. Trans., vol. 18, pp. 187-204.

Manos, Constantine (1967) Depositional environment of Sparland cyclothem (Pennsylvanian), Illinois and Forest City Basins: Bull. Amer. Assoc. Petrol. Geol., vol. 51, pp. 1843-1861.

Manspeizer, Warren (1969) The Catskill delta complex; distributaries in the Bradford subdelta: Geol. Soc. Amer., Northeast Sec., 4th Ann. Mtg., Program with Abs., p. 39.

Manzanares, A. A., de Araujo Coutinho, I., and Henriques, R. G. (1966) The Zambezi delta scheme: Trans., 6th Cong. Int. Comm. on Irrigation and Drainage; no. 4, pp. 21.127-21.141.

Mapel, W. J. (1967) Bituminous coal resources of Texas: U. S. Geol. Survey Bull. 1242-D, 27 pp.

Martin, L. F. (1959) Stratigraphy and depositional tectonics of North Yukon--Lower Mackenzie area, Canada: Bull. Amer. Assoc. Petrol. Geol., vol. 43, pp. 2399-2455.

Martin, R. H. (1967) The Recent delta of the Guadalupe River, Texas: Ph.D. Dissertation, West Virginia Univ.

------- (1969) Sedimentary variations within a deltaic sequence; Holocene Guadalupe Delta of Texas, in Some Appalachian coals and carbonates; models of ancient shallow-water deposition: West Virginia Geol. Econ. Survey, pp. 243-249.

Martin, Rudolf (1966) Paleogeomorphology and its application to exploration for oil and gas (with examples from western Canada): Bull. Amer. Assoc. Petrol. Geol., vol. 50, pp. 2277-2311.

Matthews, W. H. and Shephard, F. P. (1962) Sedimentation of Fraser River delta, British Columbia: Bull. Amer. Assoc. Petrol. Geol., vol. 46, pp. 1416-1438.

McClelland, Bramlette (1967) Progress of consolidation in delta front and prodelta clays of the Mississippi River, in Marine geotechnique--Internat. Research Conf., Monticello, Ill., 1966, Proc.: Urbana, Univ. Illinois Press, pp. 22-40.

McEwen, M. C. (1963) Sedimentary facies of the Trinity River delta: Ph.D. Dissertation, Rice Univ., 113 pp.

------- (1969) Sedimentary facies of the modern Trinity Delta, in Holocene geology of the Galveston Bay area: Houston Geol. Soc., pp. 53-77.

McGowen, J. H. (1964) The stratigraphy of the Harpersville and Pueblo formations, southwestern Stephens County, Texas: Master's Thesis Baylor Univ., 440 pp.

------- (1968) Utilization of depositional models in exploration for nonmetallic minerals: Proc., 4th Forum Geol. Industrial Minerals, Univ. Texas, Bur. Econ. Geology, pp. 157-174.

-------(1970a) Gum Hollow Delta, Nueces Bay, Texas: a depositional model for fan deltas (abst.): Gulf Coast Assoc. Geol. Socs. Trans., vol. 20, p. 262

------- Gum Hollow Fan Delta, Nueces Bay, Texas: Bur. Econ. Geology Rept. Inv. 69, 91 pp.

------- and Garner, L. E. (1969) Comparison of Recent and ancient coarse-grained point bars (abs.): Joint Program, Amer. Assoc. Petrol. Geol. and Soc. Econ. Pal. Min., 1969 Mtg., Dallas, pp. 90-91.

McGregor, A. A., and Biggs, C. A. (1968) A rich stratigraphic trap: Bull. Amer. Assoc. Petrol. Geol., vol. 52, pp. 1869-1887.

McKee, E. D. (1939) Some types of bedding in the Colorado River delta: Jour. Geology, vol. 47, pp. 64-81.

Micu T. (1965) Data on the dynamics of the seashore near the Danube Delta (trans.): Bucharest, Institutul de Studii se Cercetari Hidrotehnice, Studii de Hidrologie, vol. 9, pp. 743-804 (in Rumanian).

Mikhailov, V. N. (1958) Laws of island formation in the mouth of the rivers: USSR, Scientific reports, geol. and geogr. ser., no. 1.

------- (1959) Hydrodynamics of rivers entering a basin (trans.): Moscow, Gosudarstvennyi Okeanograficheskii Institut, Trudy, vol. 45 (in Russian).

------- (1966) Hydrology and formation of river-mouth bars., in Scientific problems of the humid tropical zone deltas and their implication: UNESCO, Proc. Dacca Symposium, pp. 59-64.

Moore, D. G., and Curray, J. R. (1964) Sedimentary framework of the drowned Pleistocene delta of Rio Grande de Santiago, Nayarit, Mexico, in Developments in sedimentology, vol. 1, Deltaic and shallow marine deposits: Internat. Sedimentological Cong., 6th, Amsterdam and Antwerp, 1963, Proc., Elsevier, Amsterdam, pp. 275-281.

------- and Scruton, P. G. (1957) Minor internal structures of some recent unconsolidated sediments: Bull. Amer. Assoc. Petrol. Geol., vol. 41, pp. 2723-2751.

Moore, Derek (1958) The Yoredale Series of Upper Wensleydale and adjacent parts of northwest Yorkshire: Yorkshire Geol. Soc., Proc., vol. 31, pp. 91-194.

------- (1959) Role of deltas in the formation of some British lower Carboniferous cyclothems: Jour. Geology, vol. 67, pp. 522-539.

------- (1966) Deltaic sedimentation: Earth Sci. Reviews, vol. 1, pp. 87-104.

Moore, G. T. (1969) Interaction of rivers and oceans--Pleistocene petroleum potential: Bull. Amer. Assoc. Petrol. Geol., vol. 53, pp. 2421-2430.

------- (1970) Role of salt wedge in bar-finger sand and delta development: Bull. Amer. Assoc. Petrol. Geol., vol. 54, pp. 326-333.

Morgan, J. P. (1952) Mudlumps at the mouths of the Mississippi River: Conf. on coastal eng. proc., 2nd, pp. 130-144.

------- (1967) Depositional processes in deltaic environment (abst.): Bull. Amer. Assoc. Petrol. Geol., vol. 51, p. 475.

------- (1970) Deltas, a resume: Jour. Geol. Education, vol. 18, pp. 107-117.

------- (ed.) (1970) Deltaic sedimentation: modern and ancient: Soc. Econ. Pal. Min. Spec. Pub. 15, 312 pp.

------- (1970) Depositional processes and products in the delta environment: Soc. Econ. Pal. Min. Spec. Pub. 15, pp. 31-47.

------- and Andersen, H. V. (1961) Genesis and paleontology of the Mississippi River mudlumps: Louisiana Geol. Survey Bull. No. 35.

-------, Coleman, J. M., and Gagliano, S. M. (1968) Mudlumps: Diapiric structures in Mississippi Delta sediments, in Diapirism and diapirs: Amer. Assoc. Petrol. Geol. Mem. 8, pp. 145-161.

------- and McIntire, W. G. (1959) Quaternary geology of the Bengal basin, East Pakistan and India: Bull. Geol. Soc. Amer., vol. 70, pp. 319-342.

-------, et al. (1963) Mudlumps at the mouth of South Pass, Mississippi River, sedimentology, origin, and relation to deltaic processes: Louisiana State Univ., Coastal Studies Ser. No. 10, 190 pp.

Morris, D. A. (1968) Lower Conemaugh (Pennsylvanian) depositional environments and paleogeography in the Appalachian coal basin: University Microfilm, Inc., Ann Arbor, Michigan, 521 pp.

Mueller, J. C., and Wanless, H. R. (1967) Differential compaction of Pennsylvanian sediments in relation to sand-shale ratios, Jefferson County, Illinois: Jour. Sed. Petrology, vol. 27, pp. 80-88.

Muller, German (1966) Die Sedimentbildung im Bodensee: Die Naturwissenschaften, vol. 53, heft. 10, pp. 237-247.

------- (1966) The new Rhine delta in Lake Constance, in Deltas in their geologic framework: Houston (Tx.) Geol. Soc., pp. 107-124.

Murphy, M. A., and Schlanger, S. O. (1962) Sedimentary structures in Ilhas and Sao Sebastiao Formations (Cretaceous), Reconcavo Basin, Brazil: Bull. Amer. Assoc. Petrol. Geol., vol. 46, pp. 457-477.

Murray, G. E. (1961) Geology of the Atlantic and Gulf Coastal Province of North America: Harper and Brothers, New York, 692 pp.

Naidu, A. S. (1966) Lithological and chemical facies changes in the Recent deltaic sediments of the Godavari River, India, in Deltas in their geologic framework: Houston (Tx.) Geol. Soc., pp. 125-157.

------- and Rao, C. B. (1965) Some aspects of Lower Godavari River and delta sediments, India (abs.): Bull. Amer. Assoc. Petrol. Geol., vol. 49, p. 354.

Nanz, R. H., Jr. (1954) Genesis of Oligocene sandstone reservoir, Seeligson field, Jim Wells and Kleberg counties, Texas: Bull. Amer. Assoc. Petrol. Geol., vol. 38, pp. 96-117.

Neagu, Fenus (1963) Delta Dunaia (Danuba delta); Goroda i peizazhi Rumynii (cities and countryside of Rumania): Bucharest, Izd-vo "Meridinae", 12 pp.

NEDECO (Netherlands Engineering Consultants) (1954) Western Niger Delta, report of investigation: The Hague, 143 pp.

------- (1961) The waters of the Niger Delta: The Hague, 317 pp.

Nelson, B. W. (1970) Hydrography, sediment dispersal, and Recent historical development of the Po River delta, Italy: Soc. Econ. Pal. Min. Spec. Pub. 15, pp. 152-184.

Nevin, C. M., and Trainer, D. W., Jr. (1927) Laboratory study in delta building: Bull. Geol. Soc. Amer., vol. 38, pp. 451-458.

Niyogi, D. (1968) Morphology and evolution of the Subarnarekha Delta, India: Geogr. Tidsskrift, vol. 67, pp. 230-240.

Noorthoorn V. d. Kruijff, J. L., and Lagaaij, R. (1960) Displaced faunas from inshore estuarine sediments in the Haringvliet (Netherlands): Geol. en Mijnbouw, vol. 39 (N. S. 22), pp. 711-723.

Norman, H. R. (1958) Irrawaddy River system of Burma: Amer. Soc. Civil Engrs., Waterways and Harbors Div., Jour., vol. 84, no. WW4, pp. 1766.1-1766.19.

Nossin, J. J. (1965) The geomorphic history of the northern Padang Delta: Jour. Tropical Geogr., vol. 20, pp. 54-64.

Nota, D. J. G. (1958) Sediments of the western Guiana Shelf--Reports of the Orinoco Shelf Expedition, 2 - Mededel: Landbouwhogeschool Wageringen, vol. 58, no. 2, pp. 1-98.

Odem, W. I. (1953) Subaerial growth of the delta of the diverted Brazos River, Texas: Compass, vol. 30, no. 3, pp. 172-178.

Off, Theodore (1963) Rhythmic linear sand bodies caused by tidal currents: Bull. Amer. Assoc. Petrol . Geol., vol. 47, pp. 324-341.

Ohya, Mashahiko (1966) Comparative study on the geomorphology and flooding in the plains of the Cho-Shui-Chi, Chao-Phya, Irrawaddy and Ganges, in Scientific problems of the humid tropical zone deltas and their implications: UNESCO, Proc. Dacca Symposium, p. 23-28.

Oliver, W. B. (1971) Depositional systems in the Woodbine Formation (Upper Cretaceous), Northeast Texas: Univ. Texas, Bur. Econ. Geology, Rept. Inv. 73, 28 pp.

------- (1971) Depositional systems in Woodbine Formation (Upper Cretaceous), northeast Texas (abst.): Bull. Amer. Assoc. Petrol. Geol., vol. 55, p. 156.

Oomkens, E. (1967) Depositional sequences and sand distribution in a deltaic complex: Geol. en Mijnbouw, vol. 46e, pp. 265-278.

------- (1970) Depositional sequences and sand distribution in the Post-glacial Rhone delta complex: Soc. Econ. Pal. Min. Spec. Pub. 15, pp. 198-212.

Ore, H. T. (1963) The braided stream depositional environment: Ph. D. Dissertation, Univ. Wyoming, 205 pp.

------- (1965) Characteristic deposits of rapidly aggrading streams: Wyoming Geol. Assoc., 19th Field Conf., Guidebook, pp. 195-201.

Ortolani, Mario, Alfieri, Nereo, and Dongus, Hansjorg (1965) Sur l'evolution morphologique de l'ancien delta du Po: Erdkunde, vol. 19, pp. 325-333.

Page, L. R., Stocking, H. E., and Smith, H. B. (compilers) (1955) Contributions to the geology of uranium and thorium by the United States Geological Survey and Atomic Energy Commission for the United Nations International Conference on Peaceful Uses of Atomic Energy, Geneva, Switzerland, 1955: U. S. Geol. Survey Prof. Paper 300.

Palain, C. (1966) Contribution a l'etude sedimentologique du "Gres a Roseaux" (Trias Superieur) en Lorraine: Sciences de la Terre, vol. 11, pp. 245-291, Nancy.

Parker, R. H. (1956) Macro-invertebrate assemblages as indicators of sedimentary environments in East Mississippi delta region: Bull. Amer. Assoc. Petrol. Geol., vol. 40, pp. 295-376.

Pascoe, E. H. (1919) Early history of the Indus, Brahmaputra and Ganges: Geol. Soc. London, Quart. Jour., vol. 75, pp. 138-157.

Paull, R. A. (1962) Depositional history of the Muddy Sandstone, Big Horn Basin, Wyoming, in Symposium on Early Cretaceous rocks of Wyoming and adjacent areas--Wyoming Geol. Assoc., 17th Ann. Field Conf., 1962: Casper, Wyo., Petroleum Inf., pp. 102-117.

Pelletier, B. R. (1958) Pocono paleocurrents in Pennsylvania and Maryland: Bull. Geol. Soc. Amer., vol. 69, pp. 1033-1063.

Pepper, J. F., et al. (1954) Geology of the Bedford Shale and Berea Sandstone in the Appalachian Basin: U. S. Geol. Survey Prof. Paper 259, 111 pp.

Petrescu, I. G. (1948) Le delta maritime du Danube; son evolution physico-geographique et les problemes qui s'y posent: Univ. Jassy, Ann. Sci., 2d sec. (Sc. Nat.), vol. 31, pp. 254-303.

------- (1967) Geomorphology of the Danube Delta (trans.): Stuttgart, Archiv fur Hydrobiologie, Supplement, vol. 30, no. 4, pp. 322-339 (in German).

Petrescu, J. (1963) Del'ta Dunaia; proiskhozhdenie i razvitie (Danube delta, its beginnings and development) Red. i posleslovie, Ia. D. Nikiforova: Moskva, Izd-vo inostr. lit-ry (Foreign Pub. House) 277 pp.

Pettijohn, F. J. (1962) Paleocurrents and paleogeography: Bull. Amer. Assoc. Petrol. Geol., vol. 46, pp. 1468-1493.

-------, et al. (1965) Geology of sand and sandstone: Indiana Geological Survey and Indiana Univ., Dept. of Geology Conference 1965: Bloomington, Ind., Indiana Geol. Survey, 207 pp.

Phleger, F. B. (1955) Ecology of foraminifera in southeastern Mississippi Delta area: Bull. Amer. Assoc. Petrol. Geol., vol. 39, pp. 712-752.

Popov, V. I., et al. (1964) Mesozoic and Cenozoic deltas of Tian-Shan and Pamir, in Deltaic and shallow marine deposits: Elsevier Pub. Co., Amsterdam, pp. 336–339.

Potter, P. E.(1962a) Regional distribution patterns of Pennsylvanian sandstones in Illinois basin: Bull. Amer. Assoc. Petrol. Geol., vol. 46, pp. 1890-1911.

------(1962b) Shape and distribution patterns of Pennsylvanian sandstone bodies in Illinois: Illinois Geol. Survey Circ. 339, 36 pp.

------ (1962c) Late Mississippian sandstones of Illinois: Illinois Geol. Survey Circ. 340, 36 pp.

------- (1963) Late Paleozoic sandstones of the Illinois Basin: Illinois Geol. Survey Rept. Inv. 217, 92 pp.

------- (1967) Sand bodies and sedimentary environments; a review: Bull. Amer. Assoc. Petrol. Geol., vol. 51, pp. 337-365.

------- and Pryor, W. A. (1961) Dispersal centers of Paleozoic and later clastics of the upper Mississippi Valley and adjacent areas: Bull. Geol. Soc. Amer., vol. 72, pp. 1195-1250.

Powers, M. C. (1967) Fluid-release mechanisms in compacting marine mudrocks and their importance in oil exploration: Bull. Amer. Assoc. Petrol. Geol., vol. 51, pp. 1240-1254.

Price, W. A. (1938) Geology of the Rio Grande Delta interpreted by geomorphology and soils (abs.): Oil & Gas Jour., vol. 36, p. 71.

------- (1954) Dynamic environments--reconnaissance mapping, geologic and geomorphic, of continental shelf of Gulf of Mexico: Gulf Coast Assoc. Geol. Socs. Trans., vol. 4, pp. 75-107.

------- (1955) Environment and formation of chenier plain: Quaternaria, vol. 2, pp. 75-86.

------- (1956) Environment and history in identification of shoreline types: Quaternaria, vol. 3, pp. 151-166.

------- (1965) Environment and formation of the chenier plain: Texas A&M Research Foundation Project 63, ONR Contract N7onr-48706, 15 pp.

Probst, D. A. (1953) Stratigraphic studies, Greater Officina, Venezuela: Bull. Amer. Assoc. Petrol. Geol., vol. 37, pp. 2073-2092.

Pryor, W. A. (1960) Cretaceous sedimentation in Upper Mississippi Embayment: Bull. Amer. Assoc. Petrol.Geol., vol. 44, pp. 1473-1504.

------- (1961) Sand trends and paleoslope in Illinois Basin and Mississippi Embayment, in Geometry of sandstone bodies: Amer. Assoc. Petrol. Geol., pp. 119-133.

Psuty, N. P. (1966) Regiones gemorficas tabasyunas, in Union Geog. Internac. Conf. Regional Latinamericana, Mexico, 1965: Proc., vol. 3, Mexico, D. F., Soc. Mex. Geog. y Estadistica, pp. 38-45.

------- (1967) The geomorphology of beach ridges in Tabasco, Mexico: Louisiana State Univ., Coastal Studies Series, No. 18, 51 pp.

Rainwater, E. H. (1963) The environmental control of oil and gas occurrence in terrigenous clastic rocks: Gulf Coast Assoc. Geol. Socs. Trans., vol. 13, pp. 79-94.

------- (1966) The geological importance of deltas, in Deltas in their geologic framework: Houston (Tx.) Geol. Soc., pp. 1-15.

Rall, R. W., and Rall, E. P. (1958) Pennsylvanian subsurface geology of Sutton and Schleicher counties, Texas: Bull. Amer. Assoc. Petrol. Geol., vol. 42, pp. 839-870.

Razavet, C. D. (1956) Contribution a l'etude geologique et sedimentologique du delta du Rhone: Soc. Geol. France, Mem. 76.

Read, W. A. (1965) Shoreward facies changes and their relation to cyclical sedimentation in part of the Namurian east of Stirling, Scotland: Scottish Jour. Geology, vol. 1, pp. 69-92.

Reed, K. J. (1969) Environment of deposition of source beds of high-wax oil; Bull. Amer. Assoc. Petrol. Geol., vol. 53, pp. 1502-1507.

Renick, B. C. (1936) The Jackson Group and the Catahoula and Oakville Formations in a part of the Texas Gulf Coastal Plain: Univ. Texas Bull. 3619.

Reyment, R. A. and Collinson, J. D. (1971) Periodicity in Namurian sediments of Derbyshire, England (a quantitative sedimentary analysis): Sed. Geology, vol. 5, pp. 23-36.

Rickard, L. V. (1964) Correlation of the Devonian rocks in New York State: New York State Mus. and Sci. Service, Geol. Survey, Map and Chart Series, no. 4.

Rodolfo, K. S. (1966) Marine sedimentation off the Irrawaddy River, Burma (abs.): Geol. Soc. Amer., Ann. Mtg., San Francisco, Program, pp. 179-180.

------- (1969) Bathymetry and marine geology of the Andaman Basin, and tectonic implications for southeast Asia: Bull. Geol. Soc. Amer., vol. 89, pp. 1203-1230.

Ross, C. A, (1969) Paleoecology of Triticites and Dunbarinella in Upper Pennsylvanian strata of Texas: Jour. Paleontology, vol. 43, pp. 298-311.

Rothrock, H. E. (1961) Deposition of the Coon Mountain Sandstone, in A study of Pennsylvanian and Permian sedimentation in the Colorado River valley of west-central Texas: Abilene Geol. Soc. Guidebook, pp. 36-38.

------- (1961) Origin of the Zweig Sandstone lens, in A study of Pennsylvanian and Permian sedimentation in the Colorado River valley of west-central Texas: Abilene Geol. Soc. Guidebook, pp. 33-35.

Russell, R. J. (1936) Physiography of lower Mississippi River delta, in Reports on the geology of Plaquemines and St. Bernard Parishes, Louisiana: Louisiana Dept. Conservation, Geol. Bull. 8, pp. 3-199.

------- (1942) Geomorphology of the Rhone delta: Assoc. Amer. Geographers Annals, vol. 32, pp. 149-254.

------- (1957) Aspects of alluvial morphology, in The earth, its crust and its atmosphere--Geomorphological and geophysical studies presented to Professor J. B. L. Hol: Leiden, Netherlands, E. J. Brill, pp. 163-174.

------- (1967) River and delta morphology: Louisiana State Univ., Coastal Studies Inst., Tech. Rept. No. 52, 55 pp.

------- (1968) Glossary of terms used in fluvial, deltaic, and coastal morphology: Louisiana State Univ., Coastal Studies Ser. 23, 97 pp.

------- and Fisk, H. N. (1942) Isostatic effects of Mississippi River delta sedimentation: Amer. Geophys. Union, pp. 56-59.

------- and Russell, R. D. (1939) Mississippi River delta sedimentation, in Recent marine sediments: Amer. Assoc. Petrol. Geol., pp. 153-177.

Ryman, L. J. (1955) Geological notes on the producing trend of the Wilcox (Eocene) of Texas: Proc. 8th Oil Recovery Conference, pp. 9-29A.

Sabins, F. F., Jr. (1965) Review of petrographic criteria for Cretaceous depositional environments: Wyoming Geol. Assoc. Guidebook, 19th Field Conf., pp. 27-34.

Saitta-Bertoni, Sandro (1969) Environment of deposition of an ancient delta; the Bluejacket Formation in northeastern Oklahoma: Assoc. Venezolana Geol. Mineria Petroleo, Bol. Infor., vol. 12, no. 5, pp. 109-150.

------- and Visher, G. S. (1968) Subsurface study of the southern portion of the Bluejacket Delta, in Geology of the Bluejacket-Bartlesville Sandstone, Oklahoma: Oklahoma City Geol. Soc., Guidebook, pp. 52-68.

Samojlov, I. V. (1952) River mouths (trans.): Moscow, Gosudar. Izd. Geografgiz Lit., 526 pp. (in Russian).

------- (1956) Die Flussmundungen: VEB Hermann Haack Geographisch-Kartographische Anstalt Gotha (translated from Russian).

Schattner, Isaac (1962) The Lower Jordon Valley--A study in the fluviomorphology of an arid region: Scripta Hierosol. (Jerusalem), no. 11, pp. 1-123.

Schlickum, V. W. R. (1968) Der Aussüflungs- und Verlandungsprozess im Bereich der Brackwassermolasse Niederbayerns: Mitt. Bay. Staatssmml. Paläont. Hist. Geol., vol. 8, pp. 327-391.

Schnable, J. E. (1966) The evolution and development of part of the northwest Florida coast: Florida State Univ., Sed. Research Lab. Contr. 12, 231 pp.

------- and Goodell, H. G. (1968) Pleistocene-Recent stratigraphy, evolution, and development of the Apalachicola Coast, Florida: Geol. Soc. Amer. Spec. Paper 112, 72 pp.

Scott, A. J. (1964) Gum Hollow Delta: comments in: Field Trip Guidebook, Depositional Environments, South-central Texas Coast, Gulf Coast Assoc. Geol. Socs., pp. 54-61.

Scruton, P. C. (1955) Sediments of the eastern Mississippi Delta, in Finding ancient shorelines: Soc. Econ. Pal. Min. Spec. Pub. 3, pp. 21-51.

------- (1956) Oceanography of Mississippi Delta sedimentary environments: Bull. Amer. Assoc. Petrol. Geol., vol. 40, pp. 2864-2952.

------- (1960) Delta building and the deltaic sequence, in Shepard, F. P., et al., eds., Recent sediments, northwest Gulf of Mexico: Amer. Assoc. Petrol. Geol., pp. 82-102.

------- (1961) Rocky Mountain Cretaceous stratigraphy and regressive sandstones, in Symposium on Late Cretaceous rocks, Wyoming and adjacent areas, Wyoming Geol. Assoc., 16th Ann. Field Conf., 1961: Casper, Wyo., Petroleum Inf., pp. 242-249.

------- and Moore, D. G. (1953) Distribution of turbidity off the Mississippi delta: Bull. Amer. Assoc. Petrol. Geol., vol. 37, pp. 1067-1074.

Seals, M. J. (1965) Lithostratigraphic and depositional framework, near-surface upper Pennsylvanian and lower Permian strata, southern Brazos valley, North-central Texas: Master's Thesis, Baylor Univ., 128 pp.

Sears, J. D., et al. (1941) Transgressive and regressive Cretaceous deposits in southern San Juan Basin, New Mexico: U. S. Geol. Survey Prof. Paper 193-F, pp. 101-121.

Shankle, J. D. (1960) The "Flippen" sandstone of parts of Taylor and Callahan counties, Texas, in Geological contributions: Abilene Geol. Soc., pp. 168-201.

Shannon, J. P., Jr. and A. R. Dahl (no date) Pennsylvanian deltaic stratigraphic traps, Midland Basin: 7 pp.

Shaw, E. W. (1913) The mudlumps at the mouths of the Mississippi: U. S. Geol. Survey Prof. Paper 85-B, pp. 11-27.

Shepard, F. P. (1953) Sedimentation rates in Texas estuaries and lagoons: Bull. Amer. Assoc. Petrol. Geol., vol. 37, pp. 1919-1934.

------- (1955) Delta-front valleys bordering the Mississippi distributaries: Bull. Geol. Soc. Amer., vol. 66, pp. 1489-1498.

------- (1956) Marginal sediments of the Mississippi Delta: Bull. Amer. Assoc. Petrol. Geol., vol. 40, pp. 2537-2623.

------- (1960) Mississippi Delta--marginal environments, sediments, and growth, in Shepard, F. P., et al., eds., Recent sediments, northwest Gulf of Mexico: Tulsa, Okla., Amer. Assoc. Petrol. Geol., pp. 56-81.

------- (1967) Contemporary structures in rapidly prograding deltas: Proc., 7th Int. Sed. Cong., Edinburgh.

-------, Dill, R. F., and Heezen, B. C. (1968) Diapiric intrusions in foreset slope sediments off Magdalena Delta, Colombia: Bull. Amer. Assoc. Petrol. Geol., vol. 52, pp. 2197-2207.

------- and Lankford, R. R. (1959) Sedimentary facies from shallow borings in lower Mississippi delta: Bull. Amer. Assoc. Petrol. Geol., vol. 43, pp. 2051-2067.

Shepps, V. C. (1963) Symposium on Middle and Upper Devonian stratigraphy of Pennsylvania and adjacent states: Pennsylvania Geol. Survey Bull. G-39, 301 pp.

Shirley, M. L. and Ragsdale, J. A. (eds.) (1966) Deltas in their geologic framework: Houston Geol. Soc., 251 pp.

Shuyskiy, Y. D. (1968) Dynamics of the beach of the Kiliya Arm of the Danube Delta: Oceanology, vol. 8, pp. 687-692 (English trans.).

Siever, Raymond (1951) The Mississippian-Pennsylvanian unconformity in southern Illinois: Bull. Amer. Assoc. Petrol. Geol., vol. 35, pp. 542-581.

Simon, J. A., and Hopkins, M. E. (1966) Sedimentary structures and morphology of late Paleozoic sand bodies in southern Illinois: Amer. Assoc. Petrol. Geol. Guidebook, and Illinois Geol. Survey Guidebook Series 7, 67 pp.

Sioli, H. (1966) General features of the delta of the Amazon, in Scientific problems of the humid tropical zone deltas and their implications: UNESCO, Proc. Dacca Symposium, pp. 381-390.

Smith, A. E., Jr. (compiler) and Broussard, M. L. (editor) (1971) Deltas of the world: modern and ancient: Bibliography: Houston Geological Society, Delta study group, 42 pp.

Sneider, R. M. (1965) Some oil occurrences in the Tar Springs (Mississippian) delta, Illinois (abs.): Bull. Amer. Assoc. Petrol. Geol., vol. 49, p. 358.

Stamp, L. D. (1940) The Irrawaddy River: Jour. Geograph., vol. 95, pp. 329-356.

Stanley, D. J. (1966) Petrology and stratigraphy applied to a problem of river engineering in the lower Mississippi delta, in Deltas in their geologic framework: Houston (Tx.) Geol. Soc., pp. 63-81.

Stevens, Curtis (1969) High-cost North Slope wells hold great promise for the U. S.: World Oil, vol. 168, no. 6, pp. 66-72.

Stokes, W. L. (1961) Fluvial and eolian sandstone bodies in Colorado Plateau, in Geometry of sandstone bodies--A symposium, 45th annual meeting, Atlantic City, N. J., April 25-28, 1960: Amer. Assoc. Petrol. Geol., pp. 151-178.

Strickland, C. (1940) Deltaic formation with special reference to the hydrographic processes of the Ganges and Brahmaputra: Longmans, Green & Co., Ltd., Calcutta.

Sutton, R. G. (1963) Correlation of Upper Devonian strata in south-central New York: Pennsylvania Geol. Survey, 4th ser., Bull. G-39, pp. 87-101.

------- (1969) Sedimentary structures and their environmental significance in the marine Catskill delta of New York (abs.): Program, Northeastern Section, Geol. Soc. Amer., p. 58.

-------, Bowen, Z. P., and McAlester, A. L. (1970) Marine shelf environments of the Upper Devonian Sonyea Group of New York: Bull. Geol. Soc. Amer., vol. 81, pp. 2975-2992.

Swan, S. B. St. C. (1968) Coastal classification with reference to the east coast of Malaya: Z. Geomorphol., vol. 7, pp. 114-132.

Swann, D. H. (1964) Late Mississippian rhythmic sediments of Mississippi Valley: Bull. Amer. Assoc. Petrol. Geol., vol. 48, pp. 637-658.

-------, Lineback, J. A., and Frund, Eugene (1965) The Borden Siltstone (Mississippian) Delta in southwestern Illinois: Illinois Geol. Survey Circ. 386, 20 pp.

Sykes, G. G. (1937) The Colorado delta: Carnegie Inst., Washington, Pub. 460.

Taggart, M. S., Jr., and Kaiser, A. D., Jr. (1960) Clay mineralogy of Mississippi River deltaic sediments: Bull. Geol. Soc. Amer., vol. 71, pp. 521-530.

Tanner, W. F. (1966) Late Cenozoic history and coastal morphology of the Apalachicola River region, western Florida, in Deltas in their geologic framework: Houston (Tx.) Geol. Soc., pp. 83-97.

Taylor, J. H. (1963) Sedimentary features of an ancient deltaic complex: The Wealden rocks of southeastern England: Sedimentology, vol. 2, pp. 2-28.

Terwindt, J. H. J. (1967) Mud transport in the Dutch delta area and along the adjacent coastline: Netherlands Jour. Sea Research, vol. 3, pp. 505-531.

Thomas, W. A., and Mann, C. J. (1966) Late Jurassic depositional environments, Louisiana and Arkansas: Bull. Amer. Assoc. Petrol. Geol., vol. 50, pp. 178-182.

Thompson, R. W. (1968) Tidal flat sedimentation on the Colorado River Delta, northwestern Gulf of California: Geol. Soc. Amer. Mem. 107, 133 pp.

Thompson, W. C. (1955) Sandless coastal terrain of the Atchafalaya Bay area, Louisiana, in Finding ancient shorelines: Soc. Econ. Pal. Min. Spec. Pub. no. 3, pp. 52-77.

Timashev, I. Y. (1970) Evolution of the delta portion of the Lena Valley (trans.): Moscow, Moskovskiy Universitet, Vestnik, Ser. J, vol. 25, no. 1, pp. 104-106 (in Russian, English sum.).

Tison, J. L. (1966) Problemes de sedimentation dans les deltas, in Scientific problems of the humid tropical zone deltas and their implications: UNESCO, Proc. Dacca Symposium, pp. 41-57.

Tomlinson, C. W., and McBee, W., Jr. (1959) Pennsylvanian sediments and orogenies of Ardmore district, Oklahoma, in vol. 2 of Ardmore Geol. Soc., Petroleum geology of southern Oklahoma a symposium, pp. 3-52.

Toussoun, Omar (1922) Memoire sur les Anciennes Branches du Nil, Pub. under auspices of King Fouad I (Egypt), 60 pp.

Treadwell, R. C. (1955) Sedimentology and ecology of southeast coastal Louisiana: Louisiana State Univ., Coastal Studies Inst. Tech. Rept. 6, 78 pp.

Tricart, Jean (1955a) Geomorphologic map of Senegal Delta: Bull. of Acad. Geol. Francaise, no. 251, pp. 98-117.

-------(1955b) Aspects sedimentologiques du delta du Senegal: Geol. Rundschau, vol. 43, no. 2, pp. 384-397.

------- (1956) Aspects geomorphologiques du delta du Senegal: Revue de Geomorphol. Dynamique, vol. 7, no. 5-6, pp. 65-86, also, Assoc. Geogr. Francais, Bull., no. 251-252, pp. 98-117.

------- (1959) Presentation of a sheet of the 1:50,000 Geomorphological Map of the Senegal Delta: Revue de Geomorphol. Dynamique, vol. 10, pp. 106-116.

------- (1961) Notice explicative de la carte geomorphologique du delta du Senegal: Mem. Bur. de recherches geologiques et minierea, Paris.

Trowbridge, A. C. (1930) Building of the Mississippi delta: Bull. Amer. Assoc. Petrol. Geol., vol. 14, pp. 85-107.

U. S. Army Corps of Engineers, Waterways Experiment Station (1952) Geological investigation of the Atchafalaya Basin and the problem of Mississippi River diversion: Mississippi River Comm., Vicksburg.

Van Andel, T. H. (1955) Sediments of the Rhone Delta: II, Sources and deposition of heavy minerals: Geol. en Mijnbouw, vol. 15, pp. 516-556.

------- (1960) Sources and dispersion of Holocene sediments, Northwest Gulf of Mexico, in Recent sediments, Northwest Gulf of Mexico: Amer. Assoc. Petrol. Geol., pp. 34-55.

------- (1967) The Orinoco Delta: Jour. Sed. Petrology, vol. 37, pp. 297-310.

------- and Curray, J. R. (1960) Regional aspects of modern sedimentation in northern Gulf of Mexico and similar basins, and paleogeographic significance, in Shepard, F. P., et al., eds., Recent sediments, northwestern Gulf of Mexico: Amer. Assoc. Petrol. Geol., pp. 345-364.

------- and Postma, H. (1954) Recent sediments of the Gulf of Paria, in Reports of the Orinico Shelf expedition: vol. 1, Verh. der Kon. Nederl. Adak. Wetensch, vol. 20, no. 5, 238 pp.

------- and Sachs, P. L. (1964) Sedimentation in the Gulf of Paria during the Holocene transgression; a subsurface acoustic reflection study: Jour. Marine Research, vol. 22, pp. 30-50.

Van de Graaff, W. J. E. (1971) Three Upper Carboniferous, limestone-rich, high-destructive, delta systems with submarine fan deposits, Cantabrian Mountains, Spain: Leidse Geol. Mededel., vol. 46, pp. 157-235.

Van Eden, J. G. (1970) A reconnaissance of deltaic environment in the middle Eocene of the south-central Pyrenees, Spain: Geol. en Mijnbouw, vol. 49, pp. 145-157.

Van Lopik, J. R. (1955) Recent geology and geomorphic history of central coastal Louisiana: Louisiana State Univ., Coastal Studies Inst. Tech. Rept. no. 7, 88 pp.

Vann, J. H. (1959) Landform-vegetation relationships in the Atrato delta: Assoc. Amer. Geograph. Annals, vol. 49, pp. 345-360.

Van Siclen, D. C. (1958) Depositional topography--examples and theory: Bull. Amer. Assoc. Petrol. Geol., vol. 42, pp. 1897-1913.

------- (1969) A depositional model of Late Paleozoic cycles on the Eastern Shelf, in Cyclic sedimentation in the Permian basin: West Texas Geol. Soc., pp. 17-27.

Van Straaten, L. M. J. U. (1954) Composition and structure of Recent marine sediments in the Netherlands: Leidse Geol. Meded., vol. 19, pp. 1-110.

------- (1957) Recent sandstones on the coasts of the Netherlands and of the Rhone delta: Geol. en Mijnbouw, vol. 19, pp. 196-213.

------- (1959) Littoral and submarine morphology of Rhone delta, in Proc., Coastal Geol. Conf., Louisiana State Univ., 2d Nat. Research Council, pp. 233-264, Baton Rouge.

------(1960a) Marine mollusc shell assemblages of the Rhone delta: Geol. en Mijnbouw, vol. 22, pp. 105-129.

------(1960b) Some recent advances in the study of deltaic sedimentation: Liverpool Manchester Geol. Jour., vol. 2, pp. 411-442.

------- (ed.) (1964) Developments in Sedimentology, vol. 1, Deltaic and shallow marine deposits: New York, Elsevier Pub. Co., 464 pp.

Vezzani, R. (1931) Etudes sur le delta du Po: Internat. Navigation Cong., 15th, Venice, pp. 33-356.

Visentini, M. (1940) Ricerche idrografiche del Delta del Po: Inst. Poligrafico Stato (Roma), Ufficio Idrographica Po-Parma, Pub. 14, vol. 2, 175 pp.

Visher, G. S. (1965) Use of vertical profile in environmental reconstruction: Bull. Amer. Assoc. Petrol. Geol., vol. 49, pp. 41-61.

------- (1968) Depositional framework of the Bluejacket-Bartlesville sandstone, in Geology of the Bluejacket-Bartlesville Sandstone, Oklahoma: Oklahoma City (Okla.) Geol. Soc., Guidebook, pp. 32-51.

Volker, A.(1966a) Surface hydrology of deltaic areas, in Scientific problems of the humid tropic zone deltas and their implications: UNESCO, Proc. Dacca Sym., pp. 143-150.

------ (1966b) The deltaic area of the Irrawaddy River in Burma, in Scientific problems of the humid tropic zone deltas and their implications: UNESCO, Proc. Dacca Sym., pp. 373-379.

------(1966c) Tentative classification and comparison with deltas of other climatic regions, in Scientific problems of the humid tropical zone deltas and their implications: UNESCO, Proc. Dacca Sym., pp. 399-408.

Waage, K. M. (1968) The type Fox Hills Formation, Cretaceous (Maestrichtian), South Dakota: Pt. 1, stratigraphy and paleoenvironments: Peabody Mus. Nat. History, New Haven, Bull. 27, 175 pp.

Wadsworth, A. H., Jr. (1966) Historical deltation of the Colorado River, Texas, in Deltas in their geologic framework: Houston (Tx.) Geol. Soc., pp. 99-105.

Waibel, R. (1952) Das Rheindelta im Bodensee: Bericht des osterreichischen Rhenbauleiters, Seegrunaufnahme, 10 pp.

Walker, H. J. (1961) The Colville River Delta: 1st Nat. Coastal and Shallow Wat. Res. Conf., pp. 472-474.

Walker, H. J., and Arnbourg, L. (1964) Morphology of sand dunes in a delta: Internat. Geogr. Cong., 20th, London.

Walker, R. G. (1966) Shale grit and Grindslow shales: transition from turbidite to shallow water sediments in upper Carboniferous of northern England: Jour. Sed. Petrology, vol. 36, pp. 90-114.

Waller, T. H. (1966) The stratigraphy of the Graham and Thrifty formations, southeastern Stephens County, Texas: Master's Thesis, Baylor Univ., 370 pp.

------- (1969) Lower Cisco carbonate deposition in North-central Texas, in Late Pennsylvanian shelf sediments, north-central Texas: Dallas (Tx.) Geol. Soc. Guidebook, pp. 34-39.

Wanless, H. R. (1955) Pennsylvanian rocks of eastern Interior Basin: Bull. Amer. Assoc. Petrol. Geol., vol. 39, pp. 1753-1820.

------- (1964) Local and regional factors in Pennsylvanian cyclic sedimentation, in Symposium on cyclic sedimentation: Kansas Geol. Survey Bull. 169, pp. 593-605.

------- (1969) Eustatic shifts in sea level during the deposition of Late Paleozoic sediments in the central United States, in Cyclic sedimentation in the Permian basin: West Texas Geol. Soc., pp. 41-54.

-------, Baroffio, J. R., and Trescott, P. C. (1969) Conditions of deposition of Pennsylvania coal beds, in Environments of coal deposition: Geol. Soc. Amer. Spec. Paper 114, pp. 105-142.

-------, et al. (1963) Mapping sedimentary environments of Pennsylvanian cycles: Bull. Geol. Soc. Amer., vol. 74, pp. 437-486.

-------, et al. (1965) Late Paleozoic deltas in the central and eastern United States (abs.): Bull. Amer. Assoc. Petrol. Geol., vol. 49, p. 362.

-------, et al. (1970) Late Paleozoic deltas in the central and eastern United States, in Deltaic sedimentation, modern and ancient: Soc. Econ. Pal. Min. Spec. Pub. 15, pp. 215-245.

Weimer, R. J. (1960) Upper Cretaceous stratigraphy, Rocky Mountain area: Bull. Amer. Assoc. Petrol. Geol., vol. 44, pp. 1-20.

-------(1961a) Spatial dimensions of Upper Cretaceous sandstones, Rocky Mountain area, in Geometry of sandstone bodies--A symposium, 45th ann. mtg., Atlantic City, N. J., April 25-28, 1960: Amer. Assoc. Petrol. Geol., pp. 82-97.

-------(1961b) Upper Cretaceous delta on tectonic foreland, northern Colorado and southern Wyoming: Bull. Amer. Assoc. Petrol. Geol., vol. 45, p. 417.

-------(1961c) Uppermost Cretaceous rocks in central and southern Wyoming and northwestern Colorado, in Symposium on Late Cretaceous rocks, Wyoming and adjacent areas, Wyoming Geol. Assoc., 16th Ann. Field Conf., 1961: Casper, Wyo., Petroleum Inf., pp. 17-28.

-------(1965a) Late Cretaceous deltas, Rocky Mountain region (abs.): Bull. Amer. Assoc. Petrol. Geol., vol. 49, p. 363.

-------(1965b) Stratigraphy and petroleum occurrences, Almond and Lewis Formations (Upper Cretaceous), Wamsutter Arch, Wyoming, in Sedimentation of Late Cretaceous and Tertiary outcrops, Rock Springs uplift--Wyoming Geol. Assoc., 19th Field Conf., 1965, Guidebook: Casper, Wyo. Petroleum Inf., pp. 65-80.

------ (1970) Rates of deltaic sedimentation and intrabasin deformation, Upper Cretaceous of Rocky Mountain region, in Deltaic sedimentation, modern and ancient: Soc. Econ. Pal. Min. Spec. Pub. 15, pp. 270-292.

Welder, F. A. (1959) Processes of deltaic sedimentation in the lower Mississippi River: Louisiana State Univ., Coastal Studies Inst. Tech. Rept. 12, 90 pp.

Wermund, E. G., and Jenkins, W. A., Jr. (1968) Late Pennsylvanian sand deposition in North-central Texas: Program, 1968 Ann. Mtg., South-central Sec., Geol. Soc. Amer., p. 40.

------- and ------- (1969) Late Pennsylvanian Series in North-central Texas, in A Guidebook to the Late Pennsylvanian shelf sediments, North-central Texas: Dallas (Tx.) Geol. Soc., pp. 1-11.

------- and ------- (1970) Recognition of deltas by fitting trend surfaces to Upper Pennsylvanian sandstones in north-central Texas, in Deltaic sedimentation, modern and ancient: Soc. Econ. Pal. Min. Spec. Pub. 15, pp. 256-269.

Westoll, T. S. (1968) Sedimentary rhythms in coal-bearing strata, in Coal and coal-bearing strata: New York, Elsevier Pub. Co., pp. 71-103.

Willard, B. (1939) Middle and Upper Devonian, in The Devonian of Pennsylvania: Pennsylvania Geol. Survey, 4th ser., Bull. G-19, 481 pp.

Williams, E. G., et al. (1964) Cyclic sedimentation in the Carboniferous of western Pennsylvania, in Guidebook, 29th Field Conf. Pennsylvanian Geologists, Pennsylvania State Univ., Topographic and Geologic Survey, Geology Dept., 34 pp.

------- and Ferm, J. C. (1964) Sedimentary facies in the lower Allegheny rocks of western Pennsylvania: Jour. Sed. Petrology, vol. 34, pp. 610-614.

Wolff, M. P. (1965) Sedimentologic design of deltaic sequences, Devonian Catskill complex of New York (abs.): Bull. Amer. Assoc. Petrol. Geol., vol. 49, p. 364.

Wright, M. D. (1967) Comparison of Namurian sediments of the central Pennines, England, and Recent deltaic deposits: Sed. Geology, vol. 1, no. 1, pp. 83-115.

Wulf, G. R. (1962) Lower Cretaceous Albian rocks in northern Great Plains: Bull. Amer. Assoc. Petrol. Geol., vol. 46, pp. 1371-1415.

------ (1964) Shoestring sandstones in Cretaceous Bearpaw Shale in Central Montana: Bull. Amer. Assoc. Petrol. Geol., vol. 48, pp. 1196-1198.

Wurster, P. (1964) Delta sedimentation in the German Keuper Basin, *in* Developments in Sedimentology, vol. 1, Deltaic and shallow marine deposition: Amsterdam, Elsevier Pub. Co., pp. 436-446.

------- (1964) Geologie des Schlifstandsteins: Hamburg Geol. Staatsinst. Mitt., vol. 33, 140 pp. (English translation of selected parts of text by W. E. Galloway)

------- (1968) Paläogeographie der deutschen Trias und die palägeographische Orientierung der Lettenkohle in Sudwestdeutschland: Eclogae Geol. Helvetiae, vol. 61, pp. 157-166.

Young, R. G. (1960) Dakota Group of Colorado Plateau: Bull. Amer. Assoc. Petrol. Geol., vol. 44, pp. 156-194.

Zabelin, A. V. (1948) Notes on the dynamics of deltas in sheltered areas (trans.): Voprosy Geografii, no. 7 (in Russian).

Zenkovich, V. P. (1967) Processes of coastal development: Interscience Pub., Div. of John Wiley and Sons, Inc., New York, 738 pp. (edited by J. A. Steers, translated from Russian by D. G. Fry).

Zhemchuzhnikov, J. A., *et al.* (1958) Similarities and differences between facies, facies-cyclic, and facies-tectonic methods of the study of Coal Measures: Izv. Akad. Sci. SSSR, Geol. Ser. (English trans.), Amer. Geol. Inst. No. 1, pp. 1-7.

-------, *et al.* (1959-1960) Structure and accumulation conditions of the main Coal Measures and coal seams of Middle Carboniferous age in the Donetz Basin: Akad. Nauk SSSR, Moscow, 679 pp. (Russian).

Ziegler, B. (1955) Die Sedimentation im Malm Delta der Schwabischen Alb: Jber. Mitt. oberrh. Geol. Ver., n.v. 37, pp. 29-55.

Zimmermann, R. K. (1966) Aspects of early Allegheny depositional environments in eastern Ohio: University Microfilms, Inc., Ann Arbor, Michigan 122 pp.

Zonneveld, J. I. S. (1954) Waarnemingen langs de kust van Surinam: Tijds. Nonink. Nederlandsch. Aardrijks. Genootsch., Deel 71, pp. 18-31. (Translated by P. Groot and W. A. Price, 1954, Texas A&M Research Foundation Project 63.)

------- (1968) The evolution of the coastal area of Suriname (South America): Proc. VII Cong. Intern. Assoc. Quaternary Res., vol. 8, pp. 577-589.

BARRIER-BAR SYSTEMS -- Summary

1. Definition: Barrier-bar systems develop under wave-dominated conditions with local or extensive strike reworking and redistribution of sediments. May develop as independent depositional systems or as component parts of other systems. Internal geometry of sands (varying mostly with degree of inlet shifting) and lateral facies tracts are similar. Significant differences occur in external geometry, areal and volume extent, and vertical facies association.

2. Basic types of barrier bars

    a. Destructional, in situ reworked sands in high-constructive deltas
    b. Relict and in situ reworked sands of high-destructive deltas
    c. Principal component facies in high-destructive, wave-dominated deltas
    d. Independent depositional systems developed along strike of feeding fluvial system or major delta systems

3. Facies assemblages of barrier-bar systems

    a. Shoreface facies: developed on the seaward side of the barrier and influenced primarily by waves and longshore currents
    b. Tidal inlet-influenced facies: developed in vicinity of tidal channels; processes include tidal currents, waves, and longshore currents
    c. Barrier bar-lagoonal transition facies: developed on back side of barrier; depending on local conditions, wind-transported sand, clay deposition from suspension, and biogenic activity such as root mottling may predominate; includes such features as washover fans

4. Shoreface facies

    a. Vertical sequence: coarsens upward; sedimentary structures mottled or burrowed at base or lower shoreface; overlain by ripples and disrupted laminae, festoon or trough crossbedding; complete sequence capped by low-angle cross or parallel laminae of beach deposits
    b. Boundary relationships: overlies shelf muds or older deposits; contact with shelf muds generally transitional but may be sharp, depending mostly on rate of accumulation; facies grade laterally to shelf deposits and back barrier-lagoonal deposits
    c. Geometry: very persistent along depositional strike; narrow to regional extent along dip (blanket sands); geometry dependent upon relationship of sediment supply to rate of subsidence and sea-level fluctuations

5. Tidal inlet-influenced facies: Complexity of facies relationships is much greater in vicinity of tidal inlets than along other reaches of the barrier bar; five major facies may be associated with inlets

   a. Seaside tidal deltas (ebb deltas)
   b. Lagoon-side tidal deltas (flood deltas)
   c. Channel-lag deposits
   d. Channel-fill deposits in abandoned tidal channels
   e. Accretionary units deposited by shifting and migrating tidal channels

   Axis of barrier bar may be offset, especially if tidal currents are strong

6. Barrier bar-lagoon transition: A variety of facies develop locally on the back side of barrier bars; they depend chiefly on climate and setting of barrier-bar systems; back side of barrier may be characterized by marshlands, extensive wind-tidal flats, washover fans, tidal deltas, etc.

7. Barrier-bar models and principal characteristics:

   a. Destructional sands, high-constructive delta systems

      Modern examples: Chandeleur Islands, Grand Isle, Timbalier Island, Isles Dernieres
      Sand source: primarily in situ, reworked from underlying constructive delta-front sands; availability of sand limited as source founders
      Geometry: crescent in plan; inherits shape from that of underlying delta front
      Inlets: relatively few; fairly stable due to lower energy and limited amount of sand to prevent shifting and healing
      Facies tract: inland to seaward: marsh and swamp of abandoned delta plain, bay or, commonly, open sound (barrier discontinuous and restriction only partial), low-relief barrier bar of delta-margin sand, open shelf muds
      Vertical facies sequence: generally underlain and overlain by high-constructive deltaic sequences
      Areal extent and thickness: thin, form volumetrically insignificant part of delta system, laterally discontinuous; locally destructive sand of one delta lobe may overlap those of an earlier lobe; form relatively narrow belt as inland transgression limited by sand source

   b. Destructional or relict sands, high-destructive delta systems

      Modern examples: outer banks of U. S. Carolina coast; Dog

Island, St. George Island, and St. Joseph Island of Apalachicola area; barriers of German and Netherlands coast

Sand source: primarily *in situ*, reworking from underlying sands of high-destructive delta system with minor amount reworked along strike by longshore drift; sand source fairly limited

Geometry: arcuate to cuspate in plan, shape mostly inherited from distribution of underlying cuspate, high-destructive delta system

Inlets: numerous due to relatively high marine energy (waves and tides); fairly stable due to limited longshore-drifted sand for healing and shifting

Facies tract: inland to seaward; extensive, shallow sound or embayment inundating large area of underlying high-destructive delta system, or tidal flat where tides are important, low-relief barrier bar built up of relict sands, open-shelf marine muds

Vertical facies sequence: overlies areally extensive sheet sands built up of strandplain and coastal barrier sands of high-destructive delta; embayment muds overlie similar sequence; distinguished from underlying and overlying units by inland relationship with extensive embayment muds

Areal extent and thickness: relatively thin and volumetrically insignificant; persistent along strike though broken by several small inlets, little offset at inlets

c. Coastal barriers (component facies) of high-destructive delta system

Modern examples: coastal barriers of Nile, Po, and Rhone deltas, U. S. Georgia coast; Tabasco Coast

Sand source: local channels and channel-mouth bars forming axis of high-destructive delta systems, reworked and laterally drifted by waves and longshore currents marginal to channel mouth; source of sand abundant and relatively continuous

Geometry: cuspate to arcuate in plan, thrown up marginal to channel mouth; may be symmetrical in relation to channel mouth or may be better developed on downcurrent side if longshore drift significant

Inlets: generally highly shifting due to abundant and continuous source of sand for healing; resulting internal structure may owe largely from lateral accretion in downcurrent shifting inlet; inlets may be deep. Provide abundant source of sediment to inland lagoon or bay so that these may become filled and emergent

Facies tract: (inland to seaward) relatively narrow and elongate lagoon, intermittently emergent and filled; broad barrier commonly with wide and gently sloping shoreface, open shelf marked by local prograded tidal deltas seaward of inlets

Areal extent and thickness: forms relatively thick (30 to 100 feet), sheet sand marked by longitudinal axes of thicks and thins as coastal barriers accrete seaward with high-destructive delta progradation

d. Independent barrier-bar systems laterally associated with large delta systems

Modern example: Texas coast barrier islands

Sand source: moderately abundant and relatively continuous, derived along strike from prograded large delta systems and carried by longshore drift up to a few hundred miles

Geometry: markedly straight and parallel to depositional strike over long distances; offset only at inlets with seaward offset on downcurrent side of inlet

Inlets: relatively few, generally stable and nonshifting

Facies tract: (inland to seaward) well-developed lagoonal facies, low- to moderately high-relief barrier bar, shoreface extending to water depths of about 30 feet, open shelf muds

Areal extent and thickness: forms relatively thick (up to 150 feet), lens-shaped sand bodies elongate with depositional strike; tend to persist with large-volume sediment source and form independent system; in tectonically unstable basin, several bars may be stacked, resulting in systems up to 1,000 feet thick; in more stable basins may form nearly sheet or tabular transgressive and regressive wedges

8. Mineral reservoirs: Barrier-bar sands and associated facies such as tidal deltas and washover fans constitute the principal stratigraphic type of reservoirs for oil and gas. With combined structural features the downdip or seaward side of barrier bars is productive, but most commonly the updip point of pinchout into lagoonal muds provides the stratigraphic entrapment.

STRANDPLAIN SYSTEMS -- Summary

1. Definition: Strandplains are prograding coastal areas. This progradation is due to a sediment's being transported along the strand by longshore currents. Barrier islands are distinguished from strandplains primarily by the presence of lagoonal facies. It should be stressed that a complete gradation exists from high-destructional deltas through strandplains to barrier islands. As such it is impossible to distinguish between these three models on the basis of such criteria as vertical sequences. Geometry of the framework sands and the associated facies would be necessary to separate these systems.

2. Processes: The most important processes to consider in strandplain systems are those associated with beaches and shorefaces. These are wave action and longshore currents generated by the refraction of waves. Since the intensity of both of these processes is greatest in shallow water, especially within the surf zone, the beach-shoreface is characterized by an upward coarsening of sediments.

   Other processes that are important in strandplains are storms, which construct beach ridges and washovers, and organic processes such as the modification of sedimentary structures and the accumulation of peat in association with marsh vegetation.

   Eolian processes may also be significant, especially in arid regions.

3. Principal facies: The most important strandplain facies are beach, shoreface, marsh, and, in some cases, mudflats and marsh ponds. The shoreface is characteristically burrowed, muddy sands and silts at the base, grading upward into clean sands with a variety of primary sedimentary structures. Wave-generated ripples and trough crossbedding are common. The overlying beach is generally characterized by low-angle cross-stratification and parallel laminations. Burrows are relatively uncommon, with primary sedimentary structures predominant.

   The marsh facies is characterized by fine grained sediments (muds and silts) that are root mottled and oxidized. Peats may also be formed; however, thicknesses are significantly less than peats associated with delta-plain swamps and marshes. Marsh ponds may be burrowed, contain algal mats and even small mussel banks or oyster reefs.

4. Variations in strandplains: Strandplains tend to form relatively thin, tabular units that parallel the paleostrandline of a basin. Many strandplains are associated with and located on the flanks of deltaic systems.

   The sand/mud ratio of strandplains may be quite variable. The factors influencing this variation are rate of sediment supply, wave and tidal-current intensity. Strandplains with very high mud contents may develop adjacent to deltas in areas of low wave energy and rapid sediment accumulation. The Chenier Plain of southwestern Louisiana is characterized by an alternation of sandy beach ridges and intervening muddy marshes. This facies pattern reflects changes in sediment supply due to the complex history of the Mississippi Delta. Strandplains that are primarily composed of accreting shoreface deposits are most commonly associated with high-destructional deltas. Examples of the latter type are found along the coast of Surinam and near Mazatlan, Mexico.

5. Mineral reservoirs: Like barrier-bar sands, strike-oriented strandplain sands provide excellent stratigraphic traps for oil and gas; entrapment is almost exclusively on the updip pinchout of strandplain sands; downdip or seaward sides of strandplain sands are significantly less productive unless associated with local early-developed structural closure.

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Selected References

Abbe, C. J. (1895) Remarks on the cuspate capes of the Carolina coast: Boston Soc. Nat. Hist. Proc., vol. 26, pp. 489-497.

Allen, J. R. L. (1965) Coastal geomorphology of eastern Nigeria: beach ridge, barrier islands, and vegetated tidal flats: Geol. en Minjbouw, vol. 44, pp. 1-21.

---------- (1967) A beach structure due to wind driven foam: Jour. Sed. Petrology, vol. 37, pp. 691-692.

Andrews, P. B. (1970) Facies and genesis of a hurricane washover fan, St. Joseph Island, central Texas coast: Univ. of Texas, Bur. Econ. Geology, Rept. Invest. no. 67, 147 pp.

Baars, D. L. and Seager, W. R. (1966) Depositional environment of White Rim Sandstone (Permian), Canyonlands National Park, Utah (abst.): Geol. Soc. America Absts., San Francisco Meeting, pp. 7-8.

Bagnold, R. A. (1963) Beach and nearshore processes, Part I. Mechanics of marine sedimentation, in: Hill (ed.), The Sea, vol. 3, pp. 507-528.

Barden, W. J., et al. (1934) Beach erosion at Galveston, Texas: House Doc. 400, 73rd Congress, 2nd Session, 9 pp.

Barrell, J. (1906) Relative geologic importance of continental, littoral, and marine sedimentation: Jour. Geol., vol. 14, pp. 316-362, 430-457, 524-568.

Bascom, W. H. (1951) The relationship between sand size and beach face slope: Trans. Am. Geophys. Union, vol. 32, pp. 866-874.

---------- (1964) Waves and beaches: the dynamics of the ocean surface: Anchor Books, Doubleday and Co., Garden City, N. Y., 267 pp.

Bass, N. W. (1936) Origin of the shoestring sands of Greenwood and Butler counties, Kansas: Kansas Geol. Sur. Bull., vol. 23, 135 pp.

Beall, A. O., Jr. (1968) Sedimentary processes operative along the western Louisiana shoreline: Jour. Sed. Petrology, vol. 38, pp. 869-877.

Bernard, H. A., et al. (1959) The Galveston Barrier Island and environs: a model for predicting reservoir occurrence and trend: Gulf Coast Assoc. Geol. Soc. Trans., vol. 9, pp. 221-224.

----------, et al. (1962) Recent and Pleistocene geology of southeast Texas, in Geology of the Gulf Coast and Central Texas and guidebook of excursion: Houston Geol. Soc., Ann. Mtg., Geol. Soc. Amer., pp. 175-224.

----------, et al. (1970) Recent sediments of southeast Texas--A field guide to the Brazos alluvial and deltaic plains and the Galveston Island complex: Univ. Texas, Bur. Econ. Geology, Guidebook 11, 67 pp.

Berg, D. W. and Duane, D. B. (1968) Effect of particle size and distribution on stability of artificially filled beach, Presque Isle Peninsula, Pennsylvania: Coastal Engin. Research Center, pp. 161-178.

Berryhill, H. L., Jr., et al. (1969) Criteria for recognizing ancient barrier coastlines (abst.): Amer. Assoc. Petrol. Geologists Bull., vol. 53, pp. 706-707.

Berven, R. J. (1966) Cardium sandstone bodies, Crossfield-Garrington area, Alberta: Canadian Petrol. Geol. Bull., vol. 14, no. 2, pp. 208-240.

Biederman, W. W., Jr., (1962) Distinction of shoreline environments in New Jersey: Jour. Sed. Petrology, vol. 32, pp. 181-200.

Bigarella, J. J. (1965) Sand-ridge structures from Parana Coastal Plain: Marine Geology, vol. 3, no. 4, pp. 269-279.

Bird, E. C. F. (1960) The formation of sand beach ridges: Australian Jour. Science, vol. 22, pp. 349-350.

---------- (1961) The coastal barriers of East Gippsland, Australia: Geography Jour., vol. 127, pp. 460-468.

---------- (1968) Coasts: MIT press, Cambridge, Mass. 237 pp.

Blatt, H. (1959) Effect of size and genetic quartz type on sphericity and form of beach sediments, Northern New Jersey: Jour. Sed. Petrology, vol. 29, pp. 197-207.

Bloom, A. L. (1964) Peat accumulation and compaction in a Connecticut coastal marsh: Jour. Sed. Petrology, vol. 34, pp. 599-603.

----------, and Stuiver, M. (1963) Submergence of the Connecticut coast: Science, vol. 139, pp. 332-334.

Bluck, B. J. (1967) Sedimentation of beach gravels: examples from south Wales: Jour. Sed. Petrology, vol. 37, pp. 128-156.

---------- (1969) Particle rounding in beach gravels: Geol. Mag., vol. 106, pp. 1-14.

Boon, J. D. (1967) Trend surface analysis of sand tracer distributions on a carbonate beach, Bimini, B. W. I., Jour. Geology, vol. 76, pp. 71-87.

Boyd, D. R., and Dyer, B. F. (1964) Frio Barrier System of South Texas: Gulf Coast Assoc. Geol. Soc. Trans., vol. 14, pp. 309-322.

Brouwer, A. (1953) Rythmic depositional features of the East-Surinam coastal plain: Geol. en Mijnbouw, N. S., vol. 15, pp. 226-236.

Brown, E. I. (1928) Inlets on sandy coasts: Am. Soc. Civil Engrs., Proc., vol. 54, pp. 505-553.

Bruun, P., and Battjes, J. A. (1963) Tidal inlets and littoral drift: Inter. Assoc. Hydraulic Res., Congr., 10th, London, 1963, vol. 1, pp. 123-130.

----------, and Gerristen, F. (1960) Stability of coastal inlets: North Holland Publ. Co., Amsterdam, 123 pp.

----------, et al. (1959) Natural bypassing of sand at coastal inlets: Jour. Waterways Harbors Div., Am. Soc. Civil Engrs., vol. 85, no. 4, paper 2301, pp. 75-107.

Bullard, F. M. (1942) Source of beach and river sands on Gulf Coast of Texas: Geol. Soc. Amer. Bull., vol. 53, no. 7, pp. 1021-1043.

Busch, D. A. (1959) Prospecting for stratigraphic traps: Amer. Assoc. Petrol. Geol. Bull., vol. 43, pp. 2829-2843.

Byrne, J. V., et al. (1959) The chenier plain and its stratigraphy, southwestern Louisiana: Gulf Coast Assoc. Geol. Soc. Trans., vol. 9, pp. 237-259.

Caldwell, J. M. (1956) Wave action and sand movement near Anaheim Bay, California: U. S. Army Beach Erosion Board, Tech. Mem. 68, 21 pp.

Carr, A. P. (1969) Size grading along a pebble beach, Chesil Beach, England: Jour. Sed. Petrology, vol. 39, pp. 297-312.

----------, et al. (1970) Significance of pebble size and shape in sorting by waves: Sed. Geol., vol. 4, pp. 89-101.

Chappell, J. (1967) Recognizing fossil strand lines from grain size analysis: Jour. Sed. Petrology, vol. 37, pp. 157-165.

Cherry, J. A. (1966) Sand movement along equilibrium beaches north of San Francisco: Jour. Sed. Petrology, vol. 36, pp. 341-357.

Clifton, H. E. (1969) Beach lamination, nature and origin: Marine Geology, vol. 7, pp. 553-560.

Coch, N. K. (1965) Post-miocene stratigraphy and morphology, inner coastal plain southeastern Virginia: Geog. Branch Off. Naval Res., Tech. Rept. no. 6, p. 94.

Coleman, J. M. (1966) Recent coastal sedimentation--central Louisiana coast: Louisiana State Univ., Coastal Studies Ser., no. 17, 73 pp.

Collier, A. and Hedgpeth, J. W. (1950) An introduction to the hydrography of tidal waters of Texas: Univ. Texas, Inst. Marine Sci. Pub., vol. 1, no. 2, pp. 121-194.

Cook, D. O. (1970) The occurrence and geologic work of rip currents off southern California: Marine Geology, vol. 9, pp. 173-186.

Corbeille, R. L. (1962) New Orleans barrier island: Gulf Coast Assoc. Geol. Trans., vol. 12, pp. 223-230.

Corpus Christi Geological Society (1962) Sedimentology of South Texas: Ann. Field Trip Guidebook, 83 pp.

Curray, J. R. (1963) Transgressions and regressions, in Papers in Marine Geology: Shepard Commemorative Volume, Macmillan, New York.

---------- (1964) Holocene regressive littoral sand, Costa de Nayarit, Mexico: in Deltaic and shallow marine deposits, Elsevier, Amsterdam , pp. 76-82.

---------- (1969) Shore zone sand bodies: barriers, cheniers and beach ridges, in The new concepts of continental margin sedimentation: Am. Geol. Inst. Short Course Lecture Notes, pp. JC-II-1--JC-II-18.

---------- and Moore, D. G. (1964) Holocene regressive littoral sand, Costa de Nayarit, Mexico: in Deltaic and shallow marine deposits, pp. 76-82, Elsevier, Amsterdam.

----------, et al. (1969) Holocene history of a strand plain lagoonal coast, Nayarit, Mexico: Proc. Internatl. Symposium on Coastal Lagoons, Mexico City.

Curry, W.H. and Hegna, E.T. (1970) Stratigraphic oil accumulations in the Lower Sundance Canyon Springs sandstones of Wyoming: Wyo. Geol. Assoc. Guidebook, 51 pp.

Davies, D.K., et al. (1971) Recognition of barrier environments: Bull. Amer. Assoc. Petrol. Geol., vol. 5, no. 4, pp. 550-565.

Davies, J.L. (1961) Tasmanian beach ridges in relation to sea level changes: Papers and Proc. Royal Soc. Tasmania, vol. 95, pp. 35-40.

Davis, R.A., Jr. (1965) Beach pitting, an unusual beach sand structure: Jour. Sed. Petrol., vol. 35, pp. 495-496.

deBeaumont, E. (1845) Lecons de geologie pratique: Paris, pp. 223-252.

Dickinson, K.A. and Hunter, R.E. (1970) Grain-size distributions and the depositional history of northern Padre Island, Texas (abst.), in Programs with abstracts for 1970: Geol. Soc. Amer., vol. 2, no. 4, p. 280.

Dillard, W.R., et al. (1941) Chanute oil pool, Neosho County, Kansas--a water-flooding operation, in Stratigraphic type oil fields: Amer. Assoc. Petrol. Geol., Tulsa, pp. 57-77.

Dillon, W.P. (1970) Submergence effects on a Rhode Island barrier and lagoon and inferences on the migration of barriers: Jour. Geol., vol. 78, pp. 94-107.

---------- with Conover, J.T. (1965) Formation of ice-cemented sand blocks on a beach and lithologic implications : Jour. Sed. Petrol., vol. 35, pp. 964-967.

Dobkins, J.E., Jr. (1968) Pebble shape development on Tahiti-Nui: Univ. Texas, M.A. Thesis, 100 pp.

Dolan, R. (1965) Relationships between nearshore processes and beach changes along the outer banks of North Carolina: Louisiana State Univ., Dissertation.

----------(1971) Coastal landforms: crescentic and rhythmic: Geol. Soc. Amer. Bull., vol. 82, pp. 177-180.

----------, and Ferm J. (1966) Swash processes and beach characteristics: The Professional Geographer, vol. 8, pp. 210-213.

----------, and Ferm, J.C. (1968) Cressentic landforms along the Atlantic coast of the United States: Science, vol. 159, pp. 627-629.

Doyle, L.J. (1968) Black shells and their significance as shoreline indicators: Geol. Soc. Amer., Ann. Mtg., Prog. Southeastern Sect., p. 32.

Duane, D.B. (1964) Significance of skewness in recent sediments, West Pamlico Sound, North Carolina: Jour. Sed. Petrol., vol. 34, pp. 864-874.

Duncan, J.R., Jr. (1964) The effects of water table and tidal cycle on swash-backwash sediment distribution and beach profile development: Marine Geol., vol. 2, pp. 186-197.

Eaton, R.O. (1951) Littoral processes on sandy coasts, in Johnson (ed.), Proc. 1st Conf., Coastal Engr. Council Wave Res.: Univ. Calif., Berkeley, pp. 140-154.

Egorov, E.N. (1951) Some forms of accumulative shores generated by longitudinal movement of sediment: Doklady, ANSSSR, vol. 80, no. 5.

Einstein, H.A. (1948) The movement of beach sand by water waves: Amer. Geophys. Union Trans., vol. 29, pp. 653-655.

Eisma, D. (1968) Composition, origin and distribution of Dutch coastal sands between Hoek van Holland and the Island of Vlieland: Netherlands Jour. Sea Research, vol. 4, pp. 123-267.

El-Ashry, M.T. and Wanless, H.R. (1965) The birth and early growth of a tidal delta: Jour. Geol., vol. 73, pp. 404-406.

---------- and ---------- (1965) Photo interpretation of shoreline changes between Cape Hatteras and Fear (North Carolina): Marine Geology, vol. 6, pp. 347-379.

Emery, K.O. (1944) Beach markings made by sand hoppers: Jour. Sed. Petrol., vol. 14, pp. 26-28.

---------- (1945) Entrapment of air in beach sand: Jour. Sed. Petrol., vol. 15, pp. 39-49.

---------- (1950) Contorted Pleistocene strata at Newport Beach, California: Jour. Sed. Petrol., vol. 20, pp. 111-115.

Escoffier, F.F. (1954) Traveling forelands and the shore line processes associated with them: Beach Erosion Board Bull., vol. 8, pp. 11-14.

Evans, O.F. (1939) Sorting and transportation of material in swash and backwash: Jour. Sed. Petrol., vol. 9, pp. 28-31.

---------- (1942) The origin of spits, bars, and related structures: Jour. Geol., vol. 50, pp. 846-865.

Exum, F. A. and Harms, J. C. (1968) Comparison of marine-bar with valley-fill stratigraphic traps, western Nebraska: Amer. Assoc. Petrol. Geol., vol. 52, pp. 1851-1868.

Faris, O. A. (1933) The silt load of Texas streams: U. S. Dept. Agriculture Bull. 382.

Ferm, J. C. (1962) Petrology of some Pennsylvanian sedimentary rocks: Jour. Sed. Petrology, vol. 32, pp. 104-123.

Fettke, C. R. (1941) Music Mountain oil pool, McKean County, Pennsylvania, in Stratigraphic type oil fields: Amer. Assoc. Petrol. Geol., Tulsa, pp.492-506.

Fisher, A. G. (1961) Stratigraphic record of transgressing seas in light of sedimentation Atlantic Coast, New Jersey: Amer. Assoc. Petrol. Geol. Bull., vol. 45, pp. 1656-1666.

Fisher, J. J. (1968) Barrier island formation: discussion: Geol. Soc. Amer. Bull., vol. 79, pp. 1421-1426.

---------- (1967) Origin of barrier island chain shorelines: Middle Atlantic states (abst.), Program for 1967 Annual Mtg., Geol. Soc. Amer, pp. 66-67.

Fisher, W. L. and McGowen, J. H. (1967) Depositional systems in the Wilcox Group of Texas and their relationship to occurrence of oil and gas: Gulf Coast Assoc. Geol. Soc. Trans., vol. 17, pp. 105-125.

----------, et al. (1970) Depositional systems in the Jackson Group of Texas--Their relationship to oil, gas, and uranium: Univ. Texas, Bur. Econ. Geol., Circular 70-1, 28 pp.

Fisk, H. N. (1948) Geological investigation of the Mermentau River Basin and adjacent areas in coastal Louisiana: Unpubl. report in definite project report, Mermentau River, Louisiana, App. II, U. S. Army Corps Engin., Mississippi River Comm., Vicksburg, 41 pp.

---------- (1948) Sand facies of recent Mississippi Delta deposits: Proc. 4th World Petrol. Cong., sec. 1-C, pp. 377-398.

---------- (1959) Padre Island and the Laguna Madre Flats, coastal south Texas, in R. J. Russell, chm., Second Coastal Geog. Conf.: LSU Coastal Studies Inst., pp. 103-151.

Flemming, N.C. (1964) Tank experiments on the sorting of beach material during cusp formation: Jour. Sed. Petrol., vol. 34, 112 pp.

Folk, R.L. (1960) Petrology and origin of the Tuscarora, Rose Hill and Keefer Formations, Lower and Middle Silurian of eastern West Virginia: Jour. Sed. Petrol., vol. 30, pp. 1-59.

---------- (1962) Petrography and origin of the Silurian Rochester and McKenzie Shales, Morgan County, West Virginia: Jour. Sed. Petrol., vol. 32, pp. 539-578.

Friedman, G.M. (1961) Distinction between dune, beach and river sands from their textural characteristics: Jour. Sed. Petrol., vol. 31, pp. 514-529.

---------- (1967) Dynamic processes and statistical parameters compared for size frequency distribution of beach and river sands: Jour. Sed. Petrol., vol. 37, pp. 327-354.

Fuller, A.O. (1962) Systemic fractionation of sand in the shallow marine and beach environment off the South African coast: Jour. Sed. Petrol., vol. 32, pp. 602-606.

Gealy, B.L. (1955) Topography of the continental slope in northwest Gulf of Mexico: Geol. Soc. Amer. Bull., vol. 66, no. 2, pp. 203-228.

Geijskes, D.C. (1952) On the structure and origin of the sandy ridges in the coastal zone of Surinam: Iijdschr. Kon. Ned. Aardr. Genootsch., vol. 69, pp. 225-237.

Geyer, R.A. (1951) Bibliography of oceanography, marine biology, geology, geophysics, and meteorology of the Gulf of Mexico: Texas Jour. Sci., vol. 2, no. 1, pp. 44-92.

Gibbons, G.S. (1967) Shell content in quartzose beach and dune sands, Dee Why, New South Wales: Jour. Sed. Petrol., vol. 37, pp. 869-878.

Gilbert, G.K. (1885) The topographic features of lake shores: U.S. Geol. Survey, 5th Ann. Rept., pp. 69-123.

Giles, R.T. and Pilkey (1965) Atlantic beach and dune sediments of the southern United States: Jour. Sed. Petrol., vol. 35, pp. 900-910.

Golding, R. (1964) Trace-fossils and the sedimentary surface in shallow-water marine sediments, in Deltaic and shallow marine deposits: Elsevier, Amsterdam, pp. 136-143.

Goldsmith, V. (1969) Offshore bars at Plum Island, Mass.: Univ. Mass., Coastal Research Group, Contrib. No. 1, pp. 281-289.

----------, et al. (1966) Conditions of "spectacular beach retreat" in a low energy environment: Geol. Soc. Amer. Special Paper 101, p. 360.

Goldstein, A., Jr. (1942) Sedimentary petrologic provinces of the northern Gulf of Mexico: Jour. Sed. Petrol., vol 12, no. 2, pp. 77-84.

Gorsline, D. S. (1967) Sediment-transport studies in the surf zone and inner shelf of southern California: Proc., 7th Internatl. Sedimentological Congress, Edinburgh.

Gould, H. R. and McFarlan, E., Jr. (1959) Geologic history of the Chenier Plain, southwestern Louisiana: Gulf Coast Assoc. Geol. Soc. Trans., vol. 9, pp. 261-270.

----------, et al. (1959) Recent sediments of the north-central Gulf Coastal Plain: Gulf Coast Assoc. Geol. Soc., Field Trip Guidebook, 84 pp.

Grant, U. S. (1943) Waves as a transporting agent: Amer. Jour. Sci., vol. 241, pp. 117-123.

Greensmith, J. T. and Tucker, E. V. (1969) The origin of Holocene shell deposits in the chenier plain facies of Essex (Great Britain): Marine Geology, vol. 7, pp. 403-426.

Griffith, E. G. (1966) Geology of Saber Bar, Logan and Weld counties, Colorado, Bull. Amer. Assoc. Petrol. Geol., vol. 50, pp. 2112-2118.

Gulliver, F. P. (1896) Cuspate forelands: Geog. Soc. Amer. Bull., vol. 7, pp. 399-422.

Hageman, I. B. P. (1969) Development of the western part of the Netherlands during the Holocene: Geol. en Mijn., vol. 48, pp. 373-388.

Hale, L. A. and van de Graff, F. R. (1964) Cretaceous stratigraphy and facies patterns--northeastern Utah and adjacent areas, in Guidebook to the geology and mineral resources of the Uinta Basin: Inter-mountain Assoc. Petrol. Geologists, 13th field conf., pp. 115-138.

Hand, B. M. (1967) Differentiation of beach and dune sands, using settling velocities of light and heavy minerals: Jour. Sed. Petrol., vol. 37, pp. 514-520.

Handin, J. W. (1951) The source, transportation, and deposition of beach sediment in southern California: U. S. Army Corps Engrs., Beach Erosion Board, Tech. Mem. 22, pp. 1-126.

Harms, J. C., et al. (1965) Depositional environment of the Fox Hills Sandstone near Rock Springs, Wyoming: Wyoming Geol. Assoc., 19th Field Conf., pp. 113-130.

Harris, S. A. (1959) The mechanical composition of some intertidal sands: Jour. Sed. Petrol., vol. 32, pp. 412-424.

Harrison, W. (1969) Empirical equation for foreshore changes over a tidal cycle: Marine Geology, vol. 7, pp. 529-552.

Hayes, M. O. (1967) Hydrographic control of sediment patterns and environments on depositional coasts: a model for paleogeographic reconstruction: Proc., 7th Internatl. Sedimentological Congress, Edinburgh.

---------- (1967) Hurricanes as geological agents: case studies of hurricanes Carla, 1961, and Cindy, 1963: Univ. Texas, Bur. Econ. Geol., Rept. Inves. 61, pp. 1-54.

---------- and Boothroyd, J. C. (1969) Storms as modifying agents in the coastal environment: Univ. Mass., Coastal research group, Contrib. No. 1, pp. 245-265.

---------- and Scott, A. J. (1964) Environmental complexes, south Texas coast: Gulf Coast Assoc. Geol. Soc. Trans., vol. 14, pp. 237-240.

---------- ed. (1969) Coastal environments of northeastern Mass. and New Hampshire: Eastern Sect., Soc. Econ. Paleont. Min. Guidebook, 642 p.

----------, et al. (1969) Sediment dispersal trends in the littoral zone: a problem in paleogeographic reconstruction: Univ. Mass., Contrib. No. 1, pp. 290-315.

Henry, V. J., Jr. and Hoyt, J. H. (1968) Quaternary paralic and shelf sediments of Georgia: Southeastern Geol., vol. 9, pp. 195-214.

Hey, R. W. (1967) Sections in the beach plain deposits of Dungeness, Kent: Geol. Mag., vol. 104, pp. 361-370.

High, L. R. (1969) Storms and sedimentary processes along the northern British Honduras coast: Jour. Sed. Petrol., vol 39, pp. 235-245.

Hite, M. P. (1924) Some observations of storm effects on ocean inlets: Amer. Jour. Sci., vol. 7, ser. 5, pp. 319-326.

Hollenshead, C. T. and Pritchard, R. L. (1961) Geometry of producing Mesaverde sandstones, San Juan Basin, in Geometry of sandstone bodies: Amer. Assoc. Petrol. Geol., Tulsa, pp. 98-118.

Hom-ma, M. and Sonu, C. (1962) Rhythmic patterns of longshore bars related to sediment characteristics: Conf. on Coastal Eng. Proc., 8th, pp. 1-29.

Hoover, R. A. (1969) Physiography and surface sediment facies of a Recent tidal delta, Harbor Island, central Texas coast (abst.): Univ. Texas, Dept. Geol. Sci., Ph. D. Dissertation

Horn, D. (1965) Zur geologischen Eutwicklung der sandlichen Scheimundung in Holozan: Meyniana, vol. 15, pp. 42-58.

Houston, R. S. and Murphy, J. F. (1970) Fossil beach placers in sandstones of late Cretaceous age in Wyoming and other Rocky Mountain states: Wyoming Geol. Assoc. Guidebook, pp. 241-249.

Hoyt, J. H. (1962) High-angle beach stratification, Sapelo Island, Georgia Jour. Sed. Petrol., vol. 32, pp. 309-311.

----------(1967a) Barrier island formation: Geol. Soc. Amer. Special Paper 101, p. 99.

----------(1967b) Barrier island formation: Geol. Soc. Amer. Bull., vol. 78, pp. 1125-1136.

----------(1967c) Occurrence of high angle stratification in littoral and shallow neritic environments, Central Georgia Coast: Sedimentology, vol. 8, pp. 229-238.

----------(1968a) Genesis of sedimentary deposits along coasts of submergence: Internatl. Geol. Congr., Proc., Sect. 8, pp. 311-321.

----------(1968b) Barrier island formation: reply: Geol. Soc. Amer. Bull., vol. 79, pp. 1427-1432.

---------- (1969) Chenier versus barrier, genetic and stratigraphic distinction: Amer. Assoc. Petrol. Geol., vol. 53, no. 2, pp. 299-306.

---------- (1970) Development and migration of barrier islands, northern Gulf of Mexico: discussion: Geol. Soc. Amer. Bull., vol. 81, pp. 3779-3782.

---------- and Hails, J. R. (1967) Pleistocene shoreline sediments in coastal Georgia: deposition and modification: Science, vol. 155, pp. 1541-1543.

---------- and Henry, V. J., Jr. (1963) Rhomboid ripple marks, indicator of current direction and environment: Jour. Sed. Petrol., vol. 33, pp. 604-608.

---------- and ---------- (1964) Development and geologic significance of soft beach sand: Sedimentology, vol. 3, p. 44.

---------- and ---------- (1965) Significance of inlet sedimentation in the recognition of ancient barrier islands: Wyoming Geol. Assoc., 19th Field Conf. Guidebook, pp. 190-194.

---------- and ---------- (1967) Influence of inlet migration on barrier island sedimentation: Geol. Soc. Amer. Bull., vol. 78, pp. 1125-1136, pp. 77-86.

---------- and ---------- (1971) Origin of capes and shoals along the southeastern coast of the United States: Geol. Soc. Amer. Bull., vol. 82, pp. 59-66.

---------- and Weimer, R. J. (1963) Comparison of modern and ancient beaches: Amer. Assoc. Petrol. Geol. Bull., vol. 47, no. 3, pp. 529-531.

----------, et al. (1964) Late Pleistocene and Recent sedimentation; central Georgia coast, in Geometry of sandstone bodies: Amer. Assoc. Petrol. Geol., Tulsa, pp. 98-118.

----------, et al. (1964) Late Pleistocene and Recent sedimentation, central Georgia coast, in Deltaic and shallow marine deposits: Elsevier, Amsterdam.

Ingle, J. C. (1966) The movement of beach sand: Developments in Sedimentology 5, Elsevier Publ. Co., Amsterdam, 221 pp.

Inman, D. L. (1949) Sorting of sediments in the light of fluid mechanics: Jour. Sed. Petrol., vol. 19, pp. 51-70.

---------- (1957) Wave-generated ripples in nearshore sands: U.S. Army Corps Engrs., Beach Erosion Board, Tech. Mem. 100, pp. 1-43, A1-A23.

Ippen, A. T. and Eagleson, P. S. (1955) A study of sediment sorting by waves shoaling on a plain beach: U.S. Army Beach Erosion Board, Tech. Mem., 63, pp. 1-83.

---------- and ---------- (1955) A study of sediment sorting by waves shoaling on a plain beach: MIT Hydrodyn. Lab. Tech. Rept. No. 18

Jacka, A.D. (1965) Depositional dynamics of the Almond Formation, Rock Springs Uplift, Wyoming: Wyoming Geol. Assoc., 19th Field Conf. Guidebook, pp. 81-100.

---------- (1970) Sediment economics of Upper Cretaceous sandstones in the Rocky Mountain Region: Wyoming Geol. Assoc. Guidebook, pp. 187-220.

Jennings, J.M. (1955) The influence of wave action on coastal outline in plan: Aust. Geog., vol. 6, pp. 36-44.

Johnson, D.W. (1919) Shore processes and shoreline development: Wiley and Sons, New York.

Johnson, J.W. (1956) Dynamics of nearshore sediment movement: Amer. Assoc. Petrol. Geol. Bull., vol. 40, pp. 2211-2232.

Kalkanis, G. (1964) Transportation of bed material due to wave action: U.S. Army CERC. Tech. Mem. 2, Washington D.C. 71 pp.

Kanes, W.H. (1969) Tidal inlets, tidal deltas and barrier islands versus alluvial deposits, a discussion of sedimentary criteria, in Some Appalachian coals and carbonates; models of ancient shallow water deposition: West Virginia Geol. Econ. Survey, pp. 259-262.

Keller, W.D. (1945) Size distribution of sand in some dunes, beaches and sandstones: Amer. Assoc. Petrol. Geol. Bull., vol. 29, pp. 215-221.

Kidson, C. (1963) The growth of sand and shingle spits across estuaries: Z. Geomorph., vol. 7, pp. 1-22.

King, C.A.M. (1951) Depth of disturbance of sand on sea beaches by waves: Jour. Sed. Petrol., vol. 21, pp. 131-140.

---------- (1959) Beaches and coasts: Edward Arnold Ltd., London, 403 pp.

---------- and McCullagh, M.J. (1971) A simulation model of a complex recurved spit: Jour. Geol. vol. 79, pp. 22-37.

---------- and Williams, W.W. (1949) The formation and movement of sand bars by wave action: Geogrl. Jour., vol. 113, pp. 70-85.

Kofoed, J.W. and Gorsline, D.S. (1963) Sedimentary environments in Apalachicola Bay and vicinity, Florida: Jour. Sed. Petrol., vol. 33, pp. 205-223.

Krumbein, W.C. (1939) Tidal lagoon sediments on the Mississippi Delta, in Recent Marine sediments: Amer. Assoc. Petrol. Geol., Tulsa, pp. 178-194.

----------(1944a) Shore processes and beach characteristics: U. S. Army Beach Erosion Board, Tech. Mem. 3, pp. 1-35.

----------(1944b) Shore currents and sand movement on a modern beach: U. S. Army Beach Erosion Board, Tech. Mem. 7, 25 p.

Krutak, P. R. (1970) Origin and depositional environment of the Codell sandstone member of the Carlile shale, (Upper Cretaceous) southeastern Colorado: The Mountain Geologist, vol. 7, pp. 185-204.

Kutyreo, E. I. and Bogdanov, Y. V. (1966) Fossilized sand bars in the copper-bearing stratum of the Udokanskaya Deposit (Northeastern Transbaikalia): Lithology and Mineral Resources, Consultants Bureau, March-April 1966, no. 2, pp. 150-159.

Ladd, H. S., et al. (1957) Environments and facies of existing bays on the Central Texas coast: Geol. Soc. Amer. Mem. 67, pp. 599-639.

LeBlanc, R. J. and Hodgson, W. D. (1959) Origin and development of the Texas shoreline: Gulf Coast Assoc. Geol. Soc. Trans., vol. 9, pp. 197-219.

LeFournier, J., Robert, P., and Yapaudjian, L. (1967) Un Modele de sedimentation paralique: les depots du littoral de la Manche en Picardie: Proc., 7th Internatl. Sed. Congress, Edinburgh.

Leontyev, O. K. (1969) Flandrean transgression and the genesis of barrier bars, in Wright (ed.), Quaternary Climate and Geology: Proc. INQUA., vol. 16, pp. 146-149.

---------- and Nikiforov, L. G. (1966) An approach to the problem of the origin of barrier bars: 2nd Internatl. Oceanographic Congress, Abst. of Papers, pp. 221-222.

Lewis, W. V. (1931) The effect of wave incidence on the configuration of a shingle beach: Geog. Jour., vol. 78, pp. 129-148.

---------- (1932) The formation of Dungeness foreland: Geog. Jour., vol. 80, pp. 309-324.

----------(1938) The evolution of shoreline curves: Geol. Assoc. London Proc., vol. 49, pp. 107-127.

---------- and Balchin, W. G. V. (1940) Past sea levels at Dungeness: Geog. Jour., vol. 96, pp. 258-285.

Logvinenko, N. V. and Remkov, I. N. (1964) Sedimentology of beaches on the north coast of the sea of Azov, in Developments in Sedimentology 1, Deltaic and sahllow marine deposits: Elsevier, Amsterdam, pp. 245-252.

---------- and Remizov, In. N. (1967) Stroenie plyazhei Azovskogo morya i kosaya sloistost' plyazhevogo tipa (The structures of beaches of the Sea of Azov and beach-type cross beddings): Litologiya i poleznye iskopaemye, no. 3, pp. 110-116.

Longinow, V. V., (ed.) Dynamics and morphology of sea coasts: Israel Program for Scientific Translations, TT68-50355.

Lucke, J. B. (1934) A study of Barnegat Inlet, New Jersey, and related shoreline phenomena: Shore and Beach, vol. 2, no. 2, pp. 45-93.

Martens, J. G. C. (1955) Beaches, in Recent marine sediments: Soc. Econ. Paleont. Min., Spec. Publ., no. 4, pp. 207-218, Tulsa.

Mason, C. C. (1957) Sediments of Mustang Island, Texas: Univ. of Texas, M. S. Thesis.

---------- and Folk, R. L. (1958) Differentiation of beach, dune, and eolian flat environments by size analysis, Mustang Island, Texas: Jour. Sed. Petrol., vol. 27, pp. 211-226.

McBride, E. F. and Hayes, M. O. (1962) Dune cross-bedding on Mustang Island, Texas: Amer. Assoc. Petrol. Geol. Bull., vol. 46, pp. 546-551.

McCave, I. N. (1968) Shallow and marginal marine sediments associated with the Catskill complex in the Middle Devonian of New York: Geol. Soc. Amer., Spec. Paper 106, pp. 73-107.

---------- (1969) Correlation using a sedimentological model of part of the Hamilton group (Middle Devonian), New York State: Amer. Jour. Sci., vol. 267, pp. 567-591.

McCubbin, D. G. (1965) Cretaceous strike-valley sandstones, northwestern New Mexico: Amer. Assoc. Petrol. Geol. Bull., vol. 49, p. 349.

---------- (1969) Cretaceous strike-valley sandstone reservoirs, northwestern New Mexico: Amer. Assoc. Petrol. Geol. Bull., vol. 53, pp. 2114-2140.

---------- and Brady, M. J. (1969) Depositional environment of the Almond Reservoirs, Patrick Draw Field, Wyoming: The Mountain Geologist: vol. 6, pp. 3-26.

McCullagh, M. J. and King, C. A. M. (1970) Spitsym: a FORTRAN IV computer program for spit simulation: Computer Contribution 50, D. F. Merriam, ed., Univ. Kansas, 20 pp.

McGee, W. J. (1890) Encroachment of the sea: The Forum, vol. 9, pp. 437-449.

McGowen, J.H., *et al.* (1970) Effects of hurricane Celia- a focus on environmental geologic problems of the Texas Coastal zone: Univ. Texas, Bur. Econ. Geol., Geol. Circ. 70-3, 35 pp.

McIntire, W.G. and Morgan, J.P. (1962) Recent geomorphic history of Plum Island, Massachusetts and adjacent coasts: Louisiana State Univ., Coastal Studies Inst., Tech. Rept. no. 19, 44 pp.

McKee, E. D. (1957) Primary structures in some recent sediments: Amer. Assoc. Petrol. Geol. Bull., vol. 41, pp. 1704-1747.

---------- and Sterrett, T.S. (1961) Laboratory experiments on form and structure of longshore bars and beaches: Amer. Assoc. Petrol. Geol. Special Publ., pp. 13-28.

McKenzie, P. (1958) The development of sand beach ridges: Australian Jour. Sci., vol. 20, pp. 213-214.

---------- (1958) Rip current system: Jour. Geol., vol. 66, pp. 103-113.

McMaster, R.L. (1960) Mineralogy as an indicator of beach sand movement along the Rhode Island shore: Jour. Sed. Petrol., vol. 30, pp. 404-413.

Meade, R.H. (1969) Landward transport of bottom sediment in estuaries of the Atlantic coastal plain: Jour. Sed. Petrol., vol. 39, pp. 222-234.

Miller, D.N., Jr. (1962) Patterns of barrier island sedimentation and its similarity to Lower Cretaceous Fall River stratigraphy: Wyoming Geol. Assoc., 17th Field Conf. Guidebook, pp. 232-247.

---------- (1965) Recognition and classification of marginal marine environments: Wyoming Geol. Assoc., 19th Field Conf. Guidebook, pp. 209-218.

Miller, R.L. and Zeigler, J.M. (1968) A model relating dynamics and sediment pattern in equilibrium in the region of shoaling waves, breaker zone, and foreshore: Jour. Geol., vol. 66, pp. 417-441.

Milling, M.E. and Behrens, E.W. (1966) Sedimentary structures of beach and dune deposits, Mustang Island, Texas: Univ. Texas Inst. Marine Sci., vol. 11, pp. 135-148.

Moberly, R., Jr. (1968) Loss of Hawaiian littoral sand: Jour. Sed. Petrol., vol. 38, pp. 17-34.

----------, et al. (1965) Source and variation of Hawaiian littoral sand: Jour. Sed. Petrol., vol. 35, pp. 589-598.

Monroe, F.F. (1969) Oolitic aragonite and quartz sand, Laboratory comparison under wave action: Coastal Engineering Research Center, Misc. Paper no. 1-69, 29 pp.

Moore, C.H., Jr. and Martin, K.G. (1966) Comparison of quartz and carbonate shallow marine sandstones: Amer. Assoc. Petrol. Geol. Bull., vol. 50, pp. 981-1000.

Moore, R.J. (1968) Recent sedimentation on northern Cardigan Bay, Wales: Bull. British Mus. (Nat. History), vol. 2, no. 2, 133 pp.

Morgan, J.P., et al. (1953) Occurrence and development of mud flats along the western Louisiana coast: Louisiana State Univ., Coastal Studies Inst. Tech. Rept. no. 2, 34 pp.

---------- and Larimore, P.B. (1957) Changes in the Louisiana shoreline: Gulf Coast Assoc. Geol. Soc. Trans., vol. 7, pp. 303-310.

Munch-Peterson (1950) Munch-Peterson's littoral drift formula: U.S. Army Beach Erosion Board, Bull. 4, pp. 1-31.

Murray, S.P. (1967) Control of grain dispersion by particle size and wave state: Jour. Geol., vol. 75, pp. 612-634.

Nagle, J.S. (1967) Wave and current orientation of shells: Jour. Sed. Petrol., vol. 37, pp. 1124-1138.

Nichols, M.M. (1964) Characteristics of sedimentary environments in Moriches Bay, in Papers in marine geology: MacMillan Co., pp. 363-383.

Nichols, R.L. (1961) Characteristics of beaches formed in polar climates: Amer. Jour. Sci., vol. 259, pp. 694-707.

Niedoroda, A.W. and Tanner, W.F. (1970) Preliminary study of transverse bars: Marine Geology, vol. 9, pp. 41-62.

Nossin, J.J. (1964) Beach ridges on the east coast of Malaya: Jour. Tropical Geog., vol. 18, pp. 111-117.

---------- (1965) Analysis of younger beach ridge deposits in eastern Malaya: Zeitschrift fur Geomorphologie, N.F. 9, pp. 186-208.

Oaks, R.Q., Jr. (1964) Post-Miocene stratigraphy and morphology, outer coastal plain, southeastern Virginia: Geog. Branch, Off. Naval Research, Tech. Rept. No. 5, p. 241.

Otvos, E.G., Jr. (1965) Sedimentation-erosion cycles of single tidal periods on Long Island sound beaches: Jour. Sed. Petrol., vol. 35, pp. 604-609.

---------- (1969) A subrecent beach ridge complex in southeastern Louisiana: Geol. Soc. Amer. Bull., vol. 80, pp. 2353-2358.

----------(1970a) Development and migration of barrier islands, northern Gulf of Mexico: Geol. Soc. Amer. Bull., vol. 81, pp. 241-246.

----------(1970b) Development and migration of barriers islands, northern Gulf of Mexico, Reply: Geol. Soc. Amer. Bull., vol. 81, pp. 3783-3788.

Parker, R.H. (1959) Macro-invertebrate assemblages of central Texas coastal bays and Laguna Madre: Amer. Assoc. Petrol. Geol. Bull., vol. 43, pp. 2100-2166.

Pater, J.D. (1959) Stratigraphic traps along north shelf of Anadarko Basin, Oklahoma: Amer. Assoc. Petrol. Geol. Bull.,vol. 43, pp. 39-59.

Paull, R.A. (1962) Depositional history of the Muddy Sandstone, Bighorn Basin, Wyoming: Wyoming Geol. Assoc., 17th Field Conf. Guidebook, pp. 102-177.

Pepper, J.R., et al. (1954) Geology of the Bedford shale and Berea sandstone in the Appalachian Basin: U.S. Geol. Survey, Prof. Paper 259, 111 pp.

Phleger, F.B. and Ewing, G.C.(1962) Sedimentology and oceanography of coastal lagoons in Baja, California: Geol. Soc. Amer. Bull., vol. 73, pp. 145-182.

Pickett, T.E. (1969) The modern sediments of Pamlico Sound, North Carolina: Southeastern Geol., vol. 11, pp. 53-83.

Pierce, J.W. (1969) Sediment budget along a barrier island chain: Sediment. Geol., vol. 3, pp. 5-16.

---------- (1970) Tidal inlets and washover fans: Jour. Geol., vol. 78, pp. 230-234.

---------- and Colquhoun, D.J. (in press) Evolution of barrier islands, in Meetings for 1969: Geol. Soc. Amer. Special Paper.

---------- and ---------- (1970) Holocene evolution of a portion of the North Carolina coast: Geol. Soc. Amer. Bull., vol. 81, pp. 3697-3714.

Potter, P.E.(1962a) Late Mississippian sandstones of Illinois: Illinois Geol. Survey Circ. No. 340, 36 pp.

----------(1962b) Shape and distribution patterns of Pennsylvanian sand bodies of Illinois: Illinois Geol. Survey Circ. 339, 36 pp.

---------- (1963) Late Paleozoic sandstones of Illinois Basin: Illinois Geol. Survey, Rept. Invest. 217, 92 pp.

---------- (1967) Sand bodies and sedimentary environments, a review: Amer. Assoc. Petrol. Geol. Bull., vol. 51, pp. 337-365.

Powers, M.C. and Kinsman, B. (1953) Shell accumulation in underwater sediments and their relation to thickness of the traction zone: Jour. Sed. Petrol., vol. 23, pp. 229-234.

Price, W.A. (1945) Environment and formation of the Chenier Plain: Texas A&M College, Research Found. Proj. 63, Ref. 54-64T, p. 15.

---------- (1951) Barrier island, not offshore bar: Science, vol. 113, pp. 487-488.

---------- (1954) Dynamic environments--reconnaissance mapping, geologic and geomorphic--of the continental shelf of the Gulf of Mexico: Gulf Coast Assoc. Geol. Soc. Trans., vol. 4, pp. 75-107.

---------- (1954) Environment and formation of the Chenier Plain: Texas A&M Research Found. Proj. 63, Dept. of Oceanog.

---------- (1954) Shorelines and coasts of the Gulf of Mexico, in Gulf of Mexico, its origin, waters, and marine life: U.S. Dept. Int., Fish and Wildlife Serv. Bull. 89, pp. 39-62.

---------- (1955) Environment and formation of the Chenier Plain: Quaternaria, vol. 2, pp. 75-86.

---------- (1958) Sedimentology and Quaternary geomorphology of South Texas, Gulf Coast Assoc. Geol. Soc. Trans., vol. 8, pp. 41-75.

---------- (1963) Patterns of flow and channeling in tidal inlets: Jour. Sed. Petrol., vol. 33, pp. 279-290.

Pritchard, D. W. (1967) What is an estuary: Physical viewpoint, in Lauff (ed.), Estuaries: Amer. Assoc. Adv. Sci., pp. 3-5.

Psuty, N. P. (1965) Beach ridge development in Tabasco, Mexico: Ann. Assoc. Amer. Geographers, vol. 55, no. 1, pp. 112-124.

---------- (1967) The geomorphology of beach ridges in Tabasco, Mexico: L.S.U., Coastal Studies Series, No. 18, 51 pp.

Pugh, J. C. (1953) The Porto Novo-Badagri sand ridge complex: Research notes, Dept. Geog., Univ. College Ibadan Nigeria, no. 3, pp. 3-16.

Putnam, W. C. (1937) Marine cycle of erosion for steeply-sloping shoreline of emergence: Jour. Geol., vol. 45, pp. 844-859.

----------, et al. (1960) Natural coastal environments of the world: Los Angeles.

Reinecke, H. E. (1963) Sedimentgefuge im Bereich der sudlichen nordsee: Abh. senchenberg. naturforschem. G., vol. 505, pp. 1-138.

---------- (1970) Characteristics of shoreface sediments (abst.): Amer. Assoc. Petrol. Geol. Bull., vol. 54, p. 866.

Rude, G. T. (1923) Shore changes at Cape Hatteras: Ann. Assoc. Amer. Geog., vol. 12, pp. 87-95.

Rusnak, G. A. (1960) Sediments of Laguna Madre, Texas, in Recent sediments, northwest Gulf of Mexico: Amer. Assoc. Petrol. Geol., Tulsa, pp. 152-196.

---------- (1967) Rates of sediment accumulation in modern estuaries, in Lauff (ed.) Estuaries; Amer. Assoc. Adv. Sci., pp. 180-184.

Russell, R. J. (1954) Coastal marshes of Louisiana: First Coastal Geography Conf., Louisiana State Univ., Coastal Studies Inst., pp. 40-43.

---------- (1958) Long, straight beaches: Ecologae Geologica Helvetiae, vol. 51, pp. 592-598.

----------- and Howe, H. V. (1953) Cheniers of southwestern Louisiana: Geog. Review, vol. 25, pp. 449-461.

Russell, R. R. and McIntire, W. G. (1965) Beach cusps: Geol. Soc. Amer. Bull., vol. 76, pp. 307-320.

Sabins, F. J. (1963) Anatomy of a stratigraphic trap, Bisti Field, New Mexico: Amer. Assoc. Petrol. Geol. Bull., vol. 47, pp. 193-228.

Saville, T. (1950) Model study of sand transport along an indefinitely long, straight beach: Trans. Amer. Geophys. Union, vol. 31, pp. 555-564.

Schafer, Wilhelm (1962) Aktuo-Palaontologie: Frankfurt am Main, W. Kramer, 666 pp.

Schnable, J. E. (1966) The evolution and development of part of the northwest Florida coast: Sedimentological Research Lab., Fla. State Unvi., Tallahassee, Fla., Contr. no. 12, p. 231.

Schofield, J. C. (1960) Sea level flucuations during the last 4,000 years as recorded by a chenier plain, Firth of Thames, New Zealand: New Zealand Jour. Geol. Geophys., vol. 3, pp. 467-485.

Scholl, D. W. (1963) Sedimentation in modern coastal swamps, southwestern Florida: Amer. Assoc. Petrol. Geol. Bull., vol. 47, pp. 1581-1603.

Schou, A. (1952) Direction determining influence of the wind on shoreline simplification and coastal dunes: Internatl. Congr., 17th, Proc., Internatl. Geog. Union, pp. 370-373.

Schwartz, M. L. (1967) Littoral zone tidal cycle sedimentation: Jour. Sed. Petrol., vol. 37, pp. 677-683.

Scott, A. J., et al. (1964) Depositional environments, Southcentral Texas coast: Field trip guidebook for 1964 meeting of Gulf Coast Assoc. Geol. Soc., Corpus Christi, 170 p.

----------, et al. (1969) Effects of Hurricane Beulah, 1967, on Texas coastal lagoons and barriers: Mem. Int. Symp. on Coastal Lagoons, UNAM-UNESCO, pp. 221-236.

Scruton, P. C. (1961) Rocky Mountain Cretaceous stratigraphy and regressive sandstones: Wyoming Geol. Assoc. 16th Field Conf., Guidebook, pp. 242-249.

Sears, J. D., et al. (1941) Transgressive and regressive Cretaceous deposits in southern San Juan Basin, New Mexico: U.S. Geol. Survey Prof. Paper 193-F, pp. 101-121.

Selley, R. C. (1969) Nearshore marine and continental sediments of the Sirte Basin, Libya: Quart. Jour. Geol. Soc. London, vol. 124, pp. 419-460.

Shaler, N. S. (1895) Beaches and tidal marshes of the Atlantic Coast: Natl. Geog. Mon. 1, pp. 137-168.

Shelton, J. W. (1965) Trend and genesis of lower most sandstone unit of Eagle Sandstone at Billings, Montana: Amer. Assoc. Petrol. Geol. Bull., vol. 49, pp. 1385-1397.

---------- (1967) Stratigraphic models and general criteria for recognition of alluvial, barrier-bar, and turbidity-current sand deposits: Amer. Assoc. Petrol. Geol. Bull., vol. 51, pp. 2441-2461.

Shepard, F. P. (1950) Longshore-bars and longshore troughs: U.S. Army Beach Erosion Board, Tech. Mem. 15.

---------- (1955) Sediment zones bordering the barrier islands of central Texas coast, in Finding ancient shorelines: Soc. Econ. Paleont. Min., Spec. Publ. 3, pp. 78-97.

---------- (1960) Gulf Coast barriers, in Recent sedimentation, northwestern Gulf of Mexico: Amer. Assoc. Petrol. Geol., Tulsa, pp. 197-220.

---------- and Inman, D. L. (1950) Nearshore water circulation related to bottom topography and wave refraction: Trans. Amer. Geophys. Union, vol. 31, pp. 196-212.

---------- and ---------- (1953) Areal and seasonal variations in beach and nearshore sediments at La Jolla, California: U.S. Army Beach Erosion Board, Tech. Mem. 39, pp. 1-82.

---------- and Moore, D. G. (1955) Central Texas coast sedimentation: characteristics of sedimentary environment, recent history and diagenesis: Amer. Assoc. Petrol. Geol. Bull., vol. 39, pp. 1463-1593.

---------- and Young, R. (1961) Distinguishing between beach and dune sands: Jour. Sed. Petrol., vol. 31, pp. 196-214.

----------, et al. (1941) Rip currents, a process of geological importance: Jour. Geol., vol. 49, pp. 337-369.

Sherrill, R. E., et al. (1941) Types of stratigraphic oil pools in Venango sands of northwestern Pennsylvania, in Stratigraphic type oil fields: Amer. Assoc. Petrol. Geol., Tulsa, pp. 507-538.

Shuiskii, Y. D. (1966) Akkumulyativnye formy pribrezhnoi zony na vzmor'e del'ty Dunaya kak indikatory peremeshcheniya nanosov (Accumulative littoral forms on the beaches of the Danube River delta as indicators of sediment movement): Valgus (Tallin), pp. 155-159.

Simon, J. A. and Hopkins, M. E. (1966) Sedimentary structures and morphology of late Paleozoic sand bodies in southern Illinois: Amer. Assoc. Petrol. Geol., Field trip Guidebook Series 7, p. 67.

Sonu, C. and Russell, R. J. (1966) Topographic changes in the surf profile: 10th Conf. on Coastal Eng., Proc., pp. 502-539.

Sprigg, R. C. (1950) The geology of the South-East Province, South Australia, with special reference to Quaternary coast-line migrations and modern beach developments: Geol. Survey South Australia Bull. 29, Adelaide.

Stenzel, H. B., Jr. (1966) Pelecypoda from the type locality of the Stone City Beds (Middle Eocene) of Texas: Univ. Texas, Bur. Econ. Geol., Publ. 5704, pp. 18-35.

Stewart, H. B., Jr. (1958) Sedimentary reflections of depositional environment in San Miguel Lagoon, Baja California, Mexico: Amer. Assoc. Petrol. Geol. Bull., vol. 42, pp. 2567-2618.

Strahler, A. N. (1964) Tidal cycle of changes in an equilibrium beach, Sandy Hook, New Jersey: Columbia Univ., Dept. Geol., Tech. Rept. No. 4, Proj. NR 388-057.

---------- (1966) Tidal cycle of changes in an equilibrium beach, Sandy Hook, New Jersey: Jour. Geol. vol. 74, pp. 247-268.

Swann, D. H. (1951) Watersburg sandstone oil pools of lower Wabash area, Illinois and Indiana: Amer. Assoc. Petrol. Geol. Bull., vol. 35, pp. 2561-2581.

Tanner, W. F. (1965) High-index ripple marks in the swash zone: Jour. Sed. Petrol., vol. 35, p. 968.

---------- (1966) The surf break: Key to paleogeography: Sedimentology, vol. 7, pp. 203-210.

Tanner, W. R. (1966) Late Cenozoic history and coastal morphology of the Apalachicola River region, wester Florida, in Deltas in their geologic framework: Houston Geol. Soc., Houston, pp. 83-97.

Teichmuller, M. and Teichmuller, R. (1957) Moore und Strandwall An Der Ostkuste von Lorsica: Natur und Volk, vol. 88, no. 12, pp. 421-430.

Thom, B.G. (1964) Origin of sand beach ridges: Aust. Jour. Sci., vol. 26, pp. 351.

---------- (1965) Late Quaternary coastal morphology of the Port Stephens-Myall Lakes area, N.S.W.: Royal Soc. New South Wales Jour. and Proc., vol. 96, pp. 23-36.

---------- (1967) Coastal and fluvial landforms: Horry and Marion counties, South Carolina: L.S.U. Coastal Studies Inst., Tech. Rept. No. 44, p. 75.

---------- (1970) Carolina bays in Horry and Marion counties, South Carolina: Geol. Soc. Amer. Bull., vol. 81, pp. 783-314.

Thomas, W.A. and Mann, C.J. (1966) Late Jurassic depositional environments, Louisiana and Arkansas: Amer. Assoc. Petrol. Geol. Bull., vol. 50, pp. 170-182.

Thompson, W.O. (1937) Original structures of beaches, bars and dunes: Geol. Soc. Amer. Bull., vol. 48, pp. 723-751.

Tietze, W. (1962) A contribution to the geomorphological problem of strand-flats: Petermanns geogr. Mitt., vol. 106, pp. 1-20.

Ting, S. (1936) Beach ridges and other shore deposits in southwest Jura: Scottish Geogr. Mag., vol. 52, pp. 182-187.

Todd, T.W. (1968) Dynamic diversion: influence of longshore current-tidal flow interaction on chenier and barrier island plains: Jour. Sed. Petrol., vol. 38, pp. 734-746.

Vandorston, P.L. (1970) Environmental analysis of Swan Peak Formation in Bear River Range, northcentral and eastern Idaho: Amer. Assoc. Petrol. Geol. Bull., vol. 54, pp. 1140-1154.

Van Lopik, J.R. and McIntire, W.G. (1957) Cheniers of Vermilion Parish, Louisiana--their relationship to Mississippi River chronology: Gulf Coast Assoc. Geol. Soc. Trans., vol. 7, p. 302.

Vann, J.H. (1959) The geomorphology of the Guiana Coast: Second Coastal Geogr. Cong., L.S.U. Coastal Studies Inst., pp. 153-187.

Van Straaten, L.M.J.U. (1953) Rhythmic patterns on Dutch North Sea beaches: Geol. en Mijn., vol. 15.

---------- (1965a) Coastal barrier deposits in south and north Holland: Meded. geol. Sticht., vol. 17, pp. 41-75.

Venkatarathnam K. (1970) Formation of the barrier spit and other sand ridges near Chilka Lake on the east coast of India: Marine Geology, vol. 9, pp. 101-116.

Warme, J. E. (1965) Distribution and relationship of sediments and organisms, Muga Lagoon, California (abst.): Amer. Assoc. Petrol. Geol. Bull., vol. 49, p. 1091.

---------- (1967) Graded bedding in recent sediments of Muga Lagoon, California: Jour. Sed. Petrol., vol. 37, pp. 540-548.

Waskom, J. D. (1959) Roundness as an indicator of environment along the coast of panhandle, Florida: Jour. Sed. Petrol., vol. 28, pp. 351-360.

Webb, J. E. (1958) The ecology of Lagos Lagoon, I. The lagoons of the Guinea Coast: Phil. Trans. Royal Soc. London, Ser. B, vol. 241, pp. 307 - 318.

Weidie, A. E. (1968) Bar and barrier island sand: Gulf Coast Assoc. Geol. Soc. Trans., vol. 18, pp. 405-415.

Weimer, R. J. (1960) Upper Cretaceous stratigraphy, Rocky Mountain area: Amer. Assoc. Petrol. Geol. Bull., vol. 44, pp. 1-20.

---------- (1965) Stratigraphy and petroleum occurrences, Almond and Lewis formations (Upper Cretaceous), Wamsutter Arch, Wyoming: Wyoming Geol. Assoc., 19th Field Conf. Guidebook, pp. 65-81.

Wermund, E. G. (1965) Cross-bedding the Meridian Sand: Sedimentology, vol. 5, pp. 69-79.

West, T. S., Jr. (1963) Typical stratigraphic traps, Jackson trend of South Texas: Gulf Coast Assoc. Geol. Soc. Trans., vol. 13, pp. 67-78.

Wolfe, R. T., Jr. (1963) The correlation of Upper Devonian Chemung sands in west-central Pennsylvania, north of Pittsburg: Penn. Geol. Survey, 45th ser., Bull. G-39, pp. 241-249.

Woncik, J. (1969) Recluse Field, Campbell County, Wyoming: The Mountain Geologist, vol. 6, pp. 221-226.

Zeigler, J.M. (1959) Origin of the sea island of southeastern United States: Geog. Rev., vol. 49, pp. 22-237.

----------, et al. (1959) Beach changes during storms on outer Cape Cod, Massachusetts: Jour. Geol., vol. 67, pp. 318-336.

---------- (1964) Some modern approaches to beach studies: Oceanogr. Mar. Biol. Ann. Rev., vol. 2, pp. 77-95.

Zenkovitch, V.P. (1959) On the genesis of cuspate spits along lagoon shores: Jour. Geol., vol. 67, pp. 269-277.

----------(1962) Some new exploration results about sand shores development during the sea transgression: De Ingenieur, no. 17, Bouw en Waterbouwkunde, Vol. 9, pp. 113-121.

---------- (1964) Formation and burial of accumulative forms in littoral and near-shore marine environments: Marine Geology, vol. 1, pp. 175-180.

---------- (1967) Processes of coastal development: Interscience Publ., John Wiley and Sons, New York.

Zimmerle, W. (1964) Sedimentology of a Tertiary beach sand on the subalpine molasse trough: Recent developments in sedimentology[1]; Elsevier, Amsterdam, pp. 447-457.

Zonneveld, J.I.S. (1954) Waarnemingen langs de kust van Surinam (observations along the coast of Surinam): Tijds. Konink. Nederlandsch. Aardrijks. Genootsch, Deel 71, pp. 18-31. (translated by P. Groot and W.A. Price, 1954, Texas A&M Res. Found. Proj. 63).

BAY-LAGOON-ESTUARINE SYSTEMS -- Summary

1. Definition: A distinction is made between bays and lagoons along the Texas coast. Bays represent the lower reaches of drowned valleys and as such have their long axis at a high angle to the strand. Lagoons, on the other hand, are bodies of water trapped behind barrier islands and therefore have their long axis parallel to the strandline. This distinction is justified on the basis of differences in genesis and in the processes filling them.

2. Processes: Both bays and lagoons are shallow, semi-enclosed bodies of water. The effect of marine processes such as waves is greatly diminished by the buffering of the associated barriers. These processes, especially waves and tidal currents, still play an important role in modifying sediment characteristics and are most important in the vicinity of inlets.

   Processes associated with storms are also important, especially near inlets or storm-formed breaches in the barrier. Storms may also generate waves that erode the shoreline and result in the deposition of sandy beaches.

   Deltaic processes are associated with the rivers that flow into the bays. The most common type of deltas formed in bays are high-constructive bayhead deltas, although fan deltas or other variants may form under suitable conditions.

   Due to the relatively low rates of terrigenous sediment influx in some lagoons and bays, organic processes may be quite significant. Oysters and other forms may develop significant reefs in these coastal waters.

   Several other processes such as eolian transportation of sands from the barrier dunes or evaporation in restricted bays may be important locally.

3. Principal facies: To discuss the variations in lagoonal and bay facies it is convenient to contrast a relatively open bay with a more restricted bay or lagoon. The "open bay" has a river flowing into it forming a bayhead delta. The bay-center facies would consist of pro-delta muds, and in areas of favorable environmental conditions oyster reefs might develop with muddy inter-reef facies.

   Sands would be restricted to the bayhead delta, thin marginal shoreface and beach sands, and near tidal inlets.

   Large flood-tidal deltas may be encountered. Washover fans may also be developed near breaches in the barrier island. These washover sands overlie the fine-grained lagoonal or bay muds and form a lobate body that thickens toward the barrier. In contrast, a restricted bay or lagoon having no permanent inflow of fresh water and little exchange with the open ocean would have quite different facies. Such a "restricted bay" would lack a bayhead delta. If the bay were hypersaline, the numbers and diversity of benthonic organisms would be greatly reduced. The bay-center facies would consist predominantly of laminated muds in contrast to the reef or burrowed, fossiliferous inter-reef muds in more open bays. If evaporation rates were sufficiently high, gypsum, halite, and other evaporites might accumulate in salt pans around the margin of a "restricted bay."

Washover fans and windblown sands might make up a significant proportion of the lagoonal fill in restricted lagoons, especially due to the low rate of sediment supply from other sources.

4. Mineral reservoirs: Bay-lagoon-estuarine systems are generally poor reservoirs for oil and gas, due to the lack of permeable sand bodies; some production occurs from small bayhead deltas, generally the only sands within the systems. The importance of these systems is the mud seal and updip trap they form for barrier-bar and strandplain sands.

LAGOON, BAY & ESTUARY SYSTEMS

Selected References

Andrews, P. B. and Horn, D. R. (1964) Serpulid reefs, Baffin Bay, southeast Texas, in Field Trip Guidebook - Depositional Environments Southcentral Texas Coast; Gulf Coast Assoc. Geol. Socs. Ann. Mtg., Corpus Christi, pp. 101-120.

Austin, G. B. (1954) On the circulation and tidal flushing of Mobile Bay, Alabama - Part I: Texas A&M Coll. Res. Found. Proj. 24, Tech. Rept. 12, pp. 1-28.

Behrens, E. W. (1963) Pleistocene river valleys in Aransas and Baffin Bays, Texas: Univ. of Texas, Inst. Marine Sci. Pub., vol. 9, pp. 7-18.

------- (1969) Hurricane effects on a hypersaline bay: Mem. Int. Symp. Coastal Lagoons, UNAM-UNESCO, pp. 301-312.

Berthois, L. (1960) Etude dynamique de la sedimentation dans la Loire: Cahiers Oceanographiques, vol. 12, pp. 631-657.

Biggs, R. B. (1967) The sediments of Chesapeake Bay, in Lauff (ed.), Estuaries: Amer. Assoc. Adv. Sci. Pub., pp. 239-261.

------- (1970) Sources and distribution of suspended sediment in Northern Chesapeake Bay: Marine Geology, vol. 9, pp. 173-186.

Boothroyd, J. C. (1969) Hydraulic conditions controlling the formation of estuarine bed forms: Univ. Mass. Coastal Research Group, Contrib. No. 1, pp. 417-427.

Breuer, J. P. (1957) An ecological survey of Baffin and Alazan Bays, Texas: Univ. of Texas, Inst. Marine Sci. Pub., vol. 4, pp. 134-155.

Burns, R. E. (1965) Importance of marine influences in estuarine sedimentation, in Proc. Federal Interagency Sedimentation Conf. of 1963: U. S. Dept. Agric., Misc. Pub. No. 970, 933 pp.

Cleary, W. T. and Pilkey, O. H. (1968) Sedimentation in Onslow Bay: Southeastern Geol., Spec. Pub. No. 1, pp. 1-18.

Collier, A. and Hedgepeth, J. W. (1950) An introduction to the hydrography of tidal waters of Texas: Univ. of Texas, Inst. Marine Sci. Pub., vol. 1, pp. 121-194.

DaBoll, J. M. (1969) Holocene sediments of the Parker River Estuary, Mass.: Univ. Mass. Coastal Res. Group, Contrib. No. 1, pp. 337-355.

Dalrymple, D. W. (1964) Recent sedimentary facies of Baffin Bay, Texas: Rice Univ., Ph. D. Dissertation, 192 pp.

Elliot, A. (1958) Recent sediments of Corpus Christi and Nueces Bays, Nueces County, Texas: Univ. of Texas, Master's Thesis, 168 pp.

Emery, K. O. and Stevenson, R. E. (1957) Estuaries and lagoons--physical and chemical characteristics: Geol. Soc. Amer. Mem. 67, vol. 1, pp. 673-750.

------- and ------- (1957) Sedimentation in estuaries, tidal flats and marshes, in Hedgepeth, J. W. (ed.), Treatise on Marine Ecology and Paleoecology.

Ericson, D. B. and Stetson, H. C. (1946) Survey of the oceanographic conditions in Vineyard Sound and Buzzards Bay restricted for U. S. Naval Mine Test Facilities, October and November, 1945: Woods Hole Oceanog. Inst. Rept., 57 pp.

Ewing, G. C. and Pfleger, F. B. (1958) Tidal influence on the spacing of inlets into coastal lagoons (abs.): Amer. Geophys. Union Trans., vol. 39, p. 540.

Fagg, D. B. (1957) The recent marine sediments and Pleistocene surface of Matagorda Bay, Texas: Gulf Coast Assoc. Geol. Socs. Trans., vol. 7, pp. 119-133.

Fisher, W. L. and McGowen, J. H. (1969) Lower Eocene Lagoonal systems in the Texas Gulf Coast Basin: Mem. Int. Symp. Coastal Lagoons, UNAM-UNESCO, pp. 263-274.

Folger, D. W. (1969) Characteristics of estuarine sediments of the United States: A synthesis (abs.): Program Abs., Geol. Soc. Amer., Southeastern section, p. 23.

Glangeaud, L. (1941) Evolution morphologique et dynamic estuaries: Bull. Assoc. Geogr. Francais, 140-141:95-103.

Gorsline, D. S. (1967) Contrasts in coastal bay sediments on the Gulf and Pacific coasts, in Lauff (ed.), Estuaries; Amer. Assoc. Adv. Sci. Pub., No. 83, pp. 219-226.

Greer, S. A. (1969) Sedimentary mineralogy of the Hampton Harbor Estuary, New Hampshire and Mass.: Univ. Mass., Coastal Res. Group, Contrib. No. 1, pp. 403-414.

Guilcher, A. (1967) Origin of sediments in estuaries, in Lauff (ed.), Estuaries: Amer. Assoc. Adv. Sci. Pub. 83, pp. 149-158.

Hall, D. G. (1967) The pattern of sediment movement in the River Tyne, in Symposium on river morphology: Pub., Assoc. Internationle d'hydrologie scientifique (Gentbrugge), no. 75, pp. 117-142.

Hartwell, A. D. (1969) Holocene stratigraphy of the Marshes of the Merrimac River Estuary, Mass.: Univ. Mass. Coastal Res. Group, Contrib. No. 1, pp. 428-440.

------- and Hayes, M. O. (1969) Hydrography of the Merrimack River Estuary, Mass.: Univ. Mass. Coastal Res. Group, Contrib. No. 1, pp. 218-244.

Haven, D. S. and Morales-Alamo, R. (1968) Occurrence and transport of faecal pellets in suspension in a tidal estuary: Sed. Geology, vol. 2, pp. 141-151.

------- and ------- (1969) Biodeposition as a factor in estuarine sedimentary processes (abs.): Program Abs., Geol. Soc. Amer., Southeastern Sec., p. 33.

------- and ------- (1969) Particle removal by filter-feeding estuarine molluscs (abs.): Program Abs., Geol. Soc. Amer., Southeastern Sec., pp. 33-34.

Hayes, M. O. (1969) Forms of sand accumulation in estuaries (abs.): Program Abs., Geol. Soc. Amer., Southeastern Sec., p. 34.

-------, et al. (1969) Diagnostic primary structures of estuarine sand bodies (abs.): Univ. Mass. Coastal Res. Group, Contrib. No. 1, p. 415.

Hedgepeth, J. W. (1951) The classification of estuarine and brackish waters and the hydrographic climate: Rept. Comm. on Treatise on Marine Ecology and Paleoecology, II, pp. 49-56.

Ippen, A. T. (1966) Estuary and coastline hydrodynamics: Engineering Societies Monographs, McGraw-Hill Co., New York, 744 pp.

Jordan, G. F. (1961) Large sand waves in estuaries and in the open sea: Natl. Coastal and Shallow Water Res. Conf., 1st, Proc., Baltimore, pp. 232-236.

Krumbein, W. C. (1939) Tidal lagoon sediments on the Mississippi Delta, in Recent Marine Sediments, Amer. Assoc. Petrol. Geol., pp. 178-194; reprinted by Soc. Econ. Pal. Min. as Spec. Pub. 4, 1955.

------- and Aberdeen, E. (1937) The sediments of Barataria Bay: Jour. Sed. Petrology, vol. 7, pp. 3-17.

Kulm, L. D., and Byrne, J. V. (1967) Sediments of Yaquina Bay, Oregon, in Lauff (ed.), Estuaries: Amer. Assoc. Adv. Sci. Pub. 83, pp. 226-239.

Lafond, L. R. (1953) Application de la mettrode des indices: letude de l'evolution des sediments actuel dans le basin de la riviere Sal (Morbihan): Compte Rendv des Acades Sciences, 237, I.

------- (1954) Application de la methode des indices a l'etude des sediments du basin de la Vilaine: Revue de l'Inst. Francais du Petrole, vol. 8, pp. 108-110.

Land, L. S., and Hoyt, J. H. (1966) Sedimentation in a meandering estuary: Sedimentology, vol. 6, pp. 191-208.

Lankford, R. R., and Rehkemper, L. J. (1969) The Galveston Bay complex: A summary of characteristics, in Holocene geology of the Galveston Bay area: Houston Geol. Soc., pp. 1-11.

------- and Rogers, J. J. W. (1969) Holocene geology of the Galveston Bay area: Houston Geol. Soc., 141 pp.

Lauff, G. H. (ed.) (1967) Estuaries: Amer. Assoc. Adv. Sci. Pub. 83, Washington, D C., 757 pp.

Lohse, E. A. (1958) Geochronology of mudflats through varve analysis, in Sedimentology of South Texas: Corpus Christi Geol. Soc. Guidebook for Oct. 27 to Nov. 1, 1958 meeting of Gulf Coast Assoc. Geol. Socs., pp. 61-63.

Lucht, F. (1953) Die Sandwernderung in unteren tidegebiet der Elbe: Deutsche Hydr. Zeitschrift, vol. 6, no. 4-6.

Lucke, J. B. (1935) Bottom conditions in a tidal lagoon: Jour. Paleontology, vol. 9, pp. 101-107.

McCormic, C. L. (1969) Holocene stratigraphy of the marshes at Plum Island, Mass.: Univ. Mass. Coastal Res. Group, Contrib. No. 1, pp. 61-63.

McIntire, W. G. and Ho, C. (1969) Development of barrier island lagoons, Western Gulf of Mexico: Mem. Int. Symp. Coastal Lagoons, UNAM-UNESCO, pp. 49-62.

McMasters, R. L. (1960) Sediments of Narraganset Bay System and Rhode Island Sound, Rhode Island: Jour. Sed. Petrology, vol. 30, pp. 249-274.

Mencher, E., *et al*. (1968) Surficial sediments of Boston Harbor, Mass.: Jour. Sed. Petrology, vol. 38, pp. 79-86.

Morgan, J. P. (1967) Ephemeral estuaries of the deltaic environment, *in* Lauff (ed.), Estuaries: Amer. Assoc. Adv. Sci. Pub. 83, pp. 115-122.

Norris, R. M. (1953) Burried oyster reefs in some Texas Bays: Jour. Paleontology, vol. 27, pp. 569-576.

Parker, R. H. (1960) Ecology and distributional patterns of marine macro-invertebrates, northern Gulf of Mexico, *in* Recent sediments, Gulf of Mexico, pp. 302-337.

Phleger, F. B. and Ayala-Castanares, A. (1969) Marine geology of Topolobambo Lagoons, Sinaloa, Mexico: Mem. Int. Symp. Coastal Lagoons, UNAM-UNESCO, pp. 101-136.

Postma, H. (1967) Sediment transport and sedimentation in the estuarine environment, *in* Lauff (ed.), Estuaries: Amer. Assoc. Adv. Sci. Pub. 83, pp. 158-180.

Price, W. A. (1945) Environment and formation of the Chenier Plain: Texas A & M Coll. Res. Found. Proj. 63, Ref. 54-64T, p. 15.

------- (1947) Equilibrium of form and forces in tidal basins of coasts of Texas and Louisiana: Bull. Amer. Assoc. Petrol. Geol., vol. 31, pp. 1619-1663.

Prichard, D. W. (1952) Estuarine hydrography, in Advances in Geophysics, vol. 1, pp. 243-288: Academic Press, N. Y.

------- (1967) Observations of circulation in coastal plain estuaries, in Lauff (ed.), Estuaries: Amer. Assoc. Adv. Sci. Pub. 83, pp. 37-45.

Rusnak, G. H. (1967) Rates of sediment accumulation in modern estuaries, in Lauff (ed.), Estuaries: Amer. Assoc. Adv. Sci. Pub. 83, pp. 180-185.

Russell, R. J. (1967) Origins of estuaries, in Lauff (ed.), Estuaries: Amer. Assoc. Adv. Sci. Pub. 83, pp. 93-100.

Schubel, J. R. (1969) Transport of suspended sediment in the Upper Reaches of the Chesapeake Bay (abs.): Program Abs., Geol. Soc. Amer., Southeastern Sec., p. 73.

Schultze, E. A. and Simmons, H. B. (1957) Fresh salt-water density currents, a major cause of siltation in estuaries: U. S. Army Corps Engrs. Com. on Tidal Hydraulics, Tech. Bull. No. 2, 28 pp.

Shepard, F. P. (1953) Sedimentation rates in Texas estuaries and lagoons: Bull. Amer. Assoc. Petrol. Geol., vol. 37, pp. 1919-1934.

------- (1957) Texas bay sediments: Inst. Marine Sci., Univ. of Texas, vol. 4, pp. 5-13.

------- and Moore, D. G. (1960) Bays of Central Texas coast, in Recent sediments, northwestern Gulf of Mexico: Amer. Assoc. Petrol. Geol., Tulsa, pp. 117-152.

Stanley, D. J. (1968) Reworking of glacial sediments in the North West Arm, a fjord-like inlet on the southeast coast of Nova Scotia: Jour. Sed. Petrology, vol. 38, pp. 1224-1241.

Stewart, H. B. (1958) Sedimentary reflections of depositional environment in San Miguel Lagoon, Baja California, Mexico: Bull. Amer. Assoc. Petrol. Geol., vol. 42, pp. 2567-2618.

Warme, J. E. (1971) Paleoecological aspects of a modern coastal lagoon: Univ. California, Pubs. in Geol. Sci., vol. 87, 131 pp.

Winston, J. E. and Anderson, F. E. (1970) Bioturbation of sediments in a northern temperate estuary: Marine Geology, vol. 10, pp. 39-49.

ADDENDUM

Webb, J.E., 1958, 'The ecology of Lagos Lagoon, I. - The lagoons of the Guinea Coast', Phil. Trans. Ray Soc. London, Ser. B, Vol. 241, pp. 307-318.

TIDAL FLAT SYSTEMS

Selected References

Allen, J.R.L. (1965) Coastal geomorphology of Eastern Nigeria; Beach-ridge barrier islands and vegetated tidal flats: Geol. en Mijnbouw, vol. 44, pp. 1-21.

Battjes, J.A. (1967) Quantitative research on littoral drift and tidal inlets, in Lauff (ed.), Estuaries: Amer. Assoc. Adv. Sci., Publ. 83, pp. 185-191.

Boersma, J.R. (1969) Internal structure of some tidal megaripples on a shoal in the Westerschelde Estuary, the Netherlands: Geol. en Mijnbouw, vol. 48, pp. 409-414.

Bradley, W.H. (1957) Physical and ecological features of the Sagadohoc Bay tidal flat, Georgetown, Main, in Treatise on marine ecology and paleoecology: Geol. Soc. Amer., Mem. 67, II, pp. 641-681.

Brouwer, A. (1953) Rhythmic depositional features of the East Surinam coastal plain: Geol. en Mijnbouw, n.s. 15, pp. 226-236.

Bruun, P. (1966) Tidal inlets and littoral drift: H. Skipness Offsettrykkeri Troundheim.

Byrne, J.V., et al. (1959) The Chenier Plain and its stratigraphy, southwestern Louisiana: Gulf Coast Assoc. Geol. Soc. Trans., vol. 9, pp. 237-259.

Coastal Research Group (1969) Coastal environments; northeast Massachusetts and New Hampshire: Univ. of Mass., Contrib. No. 1, Field Trip Guidebook, 462 pp.

Coleman, J.M. (1966) Recent coastal sedimentation--central Louisiana coast: L.S.U., Coastal Studies Ser., no. 17, 73 pp.

Davidson, J. (1963) Littoral processes and morphology on Scanian-Flat coasts: Land studies in geography, Ser. A, Phys. Geog., no. 23, p. 232.

Dionne, J.C. (1969) Tidal flat erosion by ice at La Picatiere, St. Lawrence Estuary: Jour. Sed. Petrol., vol. 39, pp. 1174-1181.

Ellis, C.W. (1962) Marine sedimentary environments in the vicinity of the Norwalk Islands, Conn.: Conn. State Geol. and Nat. Hist. Surv., Bull. 94, 89 pp.

Evans, G. (1958) Some aspects of Recent sedimentation in the Wash: Ec. Geol. Helvetia 51, pp. 508-515.

---------- (1959) The development of the coastline of the Wash, England: 2nd Coastal Geogr. Conf., L.S.U., pp. 265-284.

---------- (1965) Intertidal flat sediments and their environments of deposition in the Wash: Quart. Jour. Geol. Soc. London, vol. 121, pp. 209-245.

Evans, W.E. (1970) Imbricate linear sandstone bodies of Viking Formation in Dodsland-Hoosier area of Saskatchewan, Canada: Amer. Assoc. Petrol. Geol. Bull., vol. 54, pp. 469-480.

Fisk, H.N. (1959) Padre Island and the Laguna Madre Flats, coastal south Texas: 2nd Coastal Geog. Conf., L.S.U., pp. 103-152.

Gould, H.R. and McFarlan, E., Jr. (1959) Geologic history of the Chenier Plain, southwestern Louisiana: Gulf Coast Assoc. Geol. Soc. Trans., vol. 9, pp. 261-270.

Haentzschel, W. (1939) Tidal flat deposits, in Recent marine sediments: Amer. Assoc. Petrol. Geol., Tulsa, pp. 195-206.

Hayes, M.O. (1963) Petrology of Krebs subgroup (Penn., Desmoinesian) of western Missouri: Bull. Amer. Assoc. Petrol. Geol., vol. 47, pp. 1537-1551.

Hulsemann, J. (1955) Grossrippeln und schragschictungs im Nordsee-Watt und in der Molasse: Senck.,Lethaea, vol. 36, no. 5, pp. 359-388.

Jacka, A.D. (1966) Intertidal deposits in the geologic record: Geol. Soc. Amer. Spec. Paper 87, p. 84.

Kellerhals, P. and Murray, J.W. (1969) Tidal flats at Boundary Bay, Fraser River Delta, British Columbia: Bull. Canadian Petrol. Geol., vol. 17, no. 1, pp. 67-91.

Kindle, E.M. (1930) The intertidal zone of the Wash, England: Rep-Comm. Sedimentation, 1928-29, Nat. Res. Council Reprint and Circ. 92, pp. 5-21.

Klein, G.D. (1963) Bay of Fundy intertidal zone sediments: Jour. Sed. Petrol., vol. 33, pp. 844-854.

---------- (1965) Dynamic significance of primary structures in the Middle Jurassic Great Oolite Series, southern England: Soc. Econ. Paleont. Min. Spec. Paper 12, pp. 173-191.

---------- (1967) Comparison of recent and ancient tidal flat and estuarine sediments, in Estuaries: Amer. Assoc. Adv. Sci., pub. 83, pp. 207-218.

---------- (1970) Tidal origin of a Precambrian quartzite-the lower fine-grained Quartzite (Middle Dalradian) of Islay, Scotland: Jour. Sed. Petrol. vol. 40, pp. 973-985.

---------- (1970) Depositional and dispersal dynamics of intertidal sand bars: Jour. Sed. Petrol., vol. 40, 1095-1127.

---------- and Sanders, J. E. (1963) Comparison of sediments from Bay of Fundy and Dutch Wadden Sea tidal flats: Jour. Sed. Petrol., vol. 34, pp. 18-24.

Morgan, J. P., et al. (1953) Occurrence and development of mudflats along the western Louisiana coast: L.S.U. Coastal Studies Inst., Tech. Report 2, 34 pp.

Pestrong, R. (1965) The development of drainage patterns on tidal marshes: Stanford Univ. Pub. Geol. Sci., vol. 10, 97 pp.

Postma, H. (1954) Hydrography of the Dutch Wadden Sea: a study of the relations between water movement, the transport of suspended materials and the production of organic matter: Arch. Neerl. Zool., vol. 10, pp. 1-106.

---------- (1961) Transportation and acumulation of suspended matter in the Dutch Wadden Sea: Neth. Jour. Sea Res., vol. 1, pp. 148-190.

Price, W.A. (1947) Equilibrium of form and forces in tidal basins of coast of Texas and Louisiana: Amer. Assoc. Petrol. Geol. Bull., vol. 31, pp. 1619-1663.

Reineck, H.E. (1961) Sedimentbewegerngen an Kleinrippeln in Watt: Senckenbergiana Lethaea, vol. 42, pp. 51-61.

---------- (1962) Schichtungsarten in Wattenboden: Zeitschrif. fur Pflanzerernahrung, Dugaug, Bodenkunde, vol. 99. pp. 154-159.

---------- (1963) Sedimentgefuge im Bereich der sudlichen Nordsee: Abhandl. Senckenberg. Naturforsch, Ges., 505, pp. 1-136.

---------- (1967) Layered sediments of tidal flats, beaches and shelf bottoms of the North Sea, in Estuaries: Amer. Assoc. Adv. Sci., pub. 83, pp. 191-202.

---------- and Singh, I. B. (1967) Primary sedimentary structures in the recent sediments of the Jade, North Sea: Mar. Geol., vol. 5, pp. 227-235.

Russell, R. J. (1954) Coastal marshes of Louisiana: 1st Coastal Geog. Conf., L. S. U. Coastal Studies Inst., pp. 40-43.

---------- and McIntire, W. G. (1966) Australian tidal flats: L. S. U. Coastal Studies Inst., Ser. no. 12, 48 pp.

Smith, N. D. (1968) Cyclic sedimentation in a Silurian intertidal sequence in eastern Pennsylvania: Jour. Sed. Petrol., vol. 38, pp. 1301-1304.

Straaten, L. M. J. U. van (1950) Giant ripples in tidal channels: T. Kou. Nederl. Aardrijksk. Genoot., vol. 67, pp. 76-81.

---------- (1950) Environment of formation and facies of the Wadden Sea sediments: Tijdschr. Kon. Nederl. Aadr. Gen., vol. 67, pp. 354-368.

---------- (1951) Texture and genesis of Dutch Wadden Sea sediments: Proc. 3rd Internatl. Conf. Sedimentology, Groningen-Wageningen, pp. 225-244.

---------- (1953) Megaripples in the Dutch Wadden Sea and in the Basin of Arachou (France): Geol. en Mijnbouw, n. s. 15, pp. 1-11.

----------- (1954) Sedimentology of Recent tidal flat deposits and the Psammites du Condroz (Devonian): Geol. en Mijnbouw, n. s. 16e, no. 2, pp. 25-47.

---------- (1954) Composition and structure of Recent marine sediments in the Netherlands: Leid. geol. Meded., vol. 19, pp. 1-110.

---------- (1956) Composition of shell beds formed in tidal flat environments in the Netherlands and in the Bay of Arcachon(France): Geol. en Mijn., vol. 18, pp. 209-226.

---------- (1961) Sedimentation in tidal flat areas: Alberta Soc. Petrol. Geol., vol. 9, pp. 203-226.

---------- and Kuenen, P. H. (1958) Tidal action as a cause of clay accumulation: Jour. Sed. Petrol., vol. 28, pp. 406-413.

Swift, D. J. P. and Heron, S. D., Jr. (1967) Tidal deposits in theCretaceous of the Carolina coastal plain: Sed. Geol., vol. 1, pp. 259-282.

Terwindt, J. H. J. (1967) Mud transport in the Dutch delta area and along the adjacent coastline: Netherlands Jour. Sea Research, vol. 3, no. 4, pp. 505-531.

---------- (1970) Observation on submerged sand ripples with heights ranging from 30 to 200 cm. in tidal channels of southwestern Netherlands: Geol. en Mijn., vol. 49, pp. 489-501.

----------, et al. (1963) Sediment movement and sediment properties in the tidal area of the lower Rhine (Rotterdam Waterway): Verhand. Koninkl. Nederlands geolog. mijnbouwkundig genootschap, vol. 21, pp. 243-258.

Thompson, R. W. (1965) Tidal flat sedimentation on the Colorado River Delta, NW Gulf of California: Wyo. Geol. Soc. Assoc. Guidebook, pp. 188-190.

---------- (1968) Tidal flat sedimentation on the Colorado River Delta, NW Gulf of California: Geol. Soc. Amer. Mem. 107, 133 pp.

Trefethen, J. M. and Dow, R. L. (1960) Some features of modern beach sediments: Jour. Sed. Petrol., vol. 30, pp. 589-602.

Van Veen, J. (1950) Ed-en vloedschaar systemen in de Nederlandse getijwateren: Kon. Ned. Aard. Gencot., vol. 67, no. 3, pp. 303-325.

Walker, T. R. (1967) Formation of red beds in modern and ancient deserts: Geol. Soc. Amer. Bull., vol. 78, pp. 353-368.

Wunderlich, F. (1970) Genesis and environment of the "Nellenkopfshenschichten" (Lower Emsian, Rheinian Devon) at locus typicus in comparision with modern coastal environment of the German Bay: Jour. Sed. Petrol., vol. 40, pp. 102-130.

TERRIGENOUS SHELF SYSTEMS -- Summary

1. Definition of terms

   a. Structural shelf, physiographic shelf, and shelf environment and processes: a clear distinction needs to be made between these terms.

      Structural shelf: A term used to denote a stable tectonic element or platform along the margin of a basin. Commonly used in conjunction with intracratonic basins, especially of Paleozoic age.

      Physiographic shelf: a term that refers to the submarine terrace along coastlines that is inclined gently and uniformly seaward to a depth of about 400 feet. Many Modern shelves are underlain by Pleistocene paralic (nearshore) or glacial deposits and were submerged by post-glacial sea level rise. Same as continental shelf.

      Shelf environment and processes: a term that refers to the physical, chemical, and biological environments on the physiographic or continental shelf; shelf processes are those that are in equilibrium with the shelf environment. For example, many sediments on Modern shelf areas are relict and were not deposited by processes in equilibrium with the present shelf environment.

   b. Continental shelf: shallow submerged platform bordering continents; slopes gently seaward to average depth of 400 feet; average width, 75 km; average slope, 0.1^{o}

   c. Continental slope: steeper slope below shelf break; 20 to 100 km wide; average slope, 4^{o}; extends to varying depths where change in gradient occurs; range of 1.5 to 3.5 km; marks structural edge of continent

   d. Continental rise: built up of fairly gently sloping fan of sediments lapping up foot of slope, may extend seaward several hundreds of miles over ocean floor; width up to 600 km, less than 1^{o} slope

   e. Abyssal plain: ocean basin floor

2. Types of shelf sediments

    a. Biogenic or organic sediments: calcareous skeletal debris, dominant in low latitudes on western sides of oceans where water temperatures are high; organic siliceous sediments most abundant at high latitudes on western sides of oceans in areas of cold currents, volumetrically not important

    b. Authigenic sediments: mainly phosphorite and glauconite; most abundant on modern shelves isolated from sources of other sediment types; phosphorite typical of upwelling areas, mostly at mid latitudes on east sides of oceans

    c. Terrigenous sediments: cover most of modern shelves; most of water-contributed origin; include sediments currently being deposited in equilibrium with existing shelf processes and relict sediments laid down at different sea levels and presently out of equilibrium with shelf processes

3. Continental shelf construction

    a. Fault-block dams: fault scarp serves as dam to trap sediment brought in; best shown on modern shelves in circum-Pacific belt, very young, narrow shelves; post-tectonic sediments thin, so that fault topography clearly shown in seismic profiling

    b. Organic reef dams: coral or calcareous algae reefs may form dams as effective as tectonic dams in trapping sediment; largest example is Great Barrier Reef

    c. Diapir dams: most of shelf off Louisiana and Texas interrupted by diapirs of deep-lying Louann Salt; penetrates thick sequence of strata and even rises above surface of shelf; detrital sediments in basins between diapirs show slumps, indicating discontinuous movement of diapirs; diapirs become elongate ridges along much of Mexican shelf

    d. Deposition at grade: presumably developed or constructed in absence of any sort of dam; profiles show thick section of sediments underlying both shelf and slope that show general conformity of bedding with present shelf surface; principal origin of these kinds of shelves related to prodelta progradation and thick accumulation of mud on shelf

    e. Wave-eroded shelf: some shelves formed mainly by simple wave erosion of strata that are much older than the date of erosion; shelf surfaces cut across folded and faulted rocks and igneous intrusions; special category is ice-eroded shelf

4. Sediment character of modern shelves: extensive surface sampling of modern shelves shows about 70% of the sediments are relict, that is, out of equilibrium with normal shelf processes; these recognized by the following features:

    a. Coarse sediments lying seaward of and deeper than finer, less well sorted sands
    b. Staining of grains
    c. Glacial sediments common on shelves not now receiving glacial sediments
    d. Fresh-water and salt-marsh peats from deep parts of many shelves; submerged soils
    e. Radiocarbon dates show older rocks over wide areas of all shelves
    f. Shallow-water faunas

5. Concept of a graded shelf versus the concept of relict continental terraces: These opposing ideas concern the importance (or unimportance) of terrigenous clastic deposition in equilibrium with shelf environments. The concept of a graded shelf proposes that, given sufficient time, significant shelf deposition will occur and that these deposits will grade seaward from coarse to fine along a profile of equilibrium determined by average depth of wave base. The concept of a relict continental terrace proposes that true clastic shelf deposition is rare and that continental shelf areas are underlain principally by relict paralic sediments. According to this theory, continental margins are prograded by slope deposits periodically eroded from paralic facies, rather than by contemporaneous graded shelf and slope sedimentation.

6. Shelf processes: Not much known of shelf processes, especially depositional processes; available information (sampling, coring, bottom drifters, continuous acoustic profiling) suggests that Modern terrigenous shelf systems are chiefly nondepositional; exceptions of significance include only shelf areas off high-constructive type deltas and high-energy, commonly tide-dominated shelves where currents are sufficient to pick up, transport, and redeposit bottom sediments; those contending that the terrigenous shelf is an active depositional system hold that recent sea-level rise has put the present shelf out of equilibrium and the normal neritic shelf progradation has not had time to blanket modern shelves; proponents of significant deposition in equilibrium with shelf environments point to several examples where oceanic currents and winds may combine to produce waves sufficient to transport some clastic sediment within the shelf environment.

7. Outline of shelf processes affecting deposits

Constructive processes

- a. Suspension deposition
    1. Off deltas: technically a part of the delta system but does, of course, prograde the shelf
    2. Storm ebbs (involve some traction load)
    3. Rare wave-generated currents on very narrow shelf areas exposed to open ocean currents and waves
    4. Normal wave and current activity (longshore convergence at grade); large volume of sediment is transported inshore along the shoreface by longshore drift, but this transport-depositional mode is not in equilibrium with shelf environments.
    5. Turbidity currents, density underflows, channel infilling (chiefly traction and mostly involved shelf by-passing)

- b. Traction deposition (mostly tide-dominated shelves)
    1. Tidal current sand ridges; example, North Sea
    2. Sand-wave bodies on shelf shoals and banks
    3. Sand swells; may involve little transport
    4. Rare wave-generated currents along narrow shelves that are exposed to unusual oceanic fetch and major current systems

Destructive processes

- a. Bioturbation (addition of biogenic and chemical sediments to terrigenous shelves)

- b. Winnowing and reworking (chiefly in situ, no significant transport and no significant formation of distinct geometries)

- c. Bypassing

8. Proposed shelf depositional models

- a. Tide-dominated shelf: shelf areas characterized by tidal currents that are sufficient to unmix relict paralic or glacial deposits and transport sediment to depositional sites in equilibrium with the shelf environment. Occur in unique hydrographic settings where tide is funneled through narrow passes or channels (i. e., North Sea, Gulf of Korea) or off high destructive, tide dominated deltas

(i. e., Irrawaddy, Mekong) where river sediment is supplied directly to high energy shelf system. Facies are principally migrating elongate tidal sand bars with interbar lag deposits; bars are parallel or subparallel to current direction. Sand waves may occur in shallower areas; silt and mud is carried to lower energy areas distal to principal tidal currents. Tidal ranges up to 20 feet are common and currents typically reach 2 knots velocity. These shelves have not been recognized in ancient basins.

b. Wave-dominated shelf: very rare today and their importance in ancient basins is highly controversial. Some Modern examples include narrow shelves along tectonically active continental margins interfacing with extremely high energy, open ocean currents and waves. Fortuitous combination of waves and currents, such as in Monterey Bay, California, parts of Gulf of Alaska, and Bering Sea, may provide sufficient energy to move clastic sediment seaward across shelf, resulting in a graded shelf deposit. Resulting facies are thin, sheetlike units that veneer underlying relict paralic or glacial sediments. Considerable doubt exists as to validity of proposed ancient examples.

c. Biogenic shelf: relict or essentially nondepositional shelf. Very thin, blanket mud deposit that is highly burrowed and covers relict paralic sediments. Sediment is dominantly shell, fecal pellets, glauconite, or phosphorites. Examples include most Modern continental shelves. Ancient example are common; occur as thin, widespread, fossiliferous units within thick, unfossiliferous clastics.

d. Carbonate shelf: total absence of terrigenous clastic source (relict or river supplied). May be associated with a sediment-starved slope system deriving carbonate turbidites from erosion of shelf-edge. West Florida shelf is a Modern example; structurally stable platform, such as Bahama area is, in part, a tide and locally wave-dominated carbonate shelf environment. Ancient examples include most subtidal carbonate facies.

9. Recognition of ancient shelf deposits: (Depositional, that is, accumulating through shelf processes, not structural shelf, which may include a variety of depositional systems)

a. Addition of significant biogenic-chemical elements: resulting in fossiliferous sediments, commonly even with diverse fauna; bioturbation extensive; glauconite and phosphorite in small amounts; as a shelf becomes a carbonate shelf, these features become dominant; significant is the relatively slow rate of sedimentation relative to nonterrigenous or in situ processes

b. Areal extent: thin, persistent muds, commonly silt-free, showing the above biogenic features

c. Shelf sands: on high-energy shelves, particularly tide-dominated shelves, currents may be capable of forming distinct sand bodies (e.g., tidal-current sand ridges of the North Sea shelf); possible sheet sands may develop on high-energy shelves in areas of tidal-current interferences (e.g., Texel Spur in North Sea); these processes involve reworking and transport of sands already on shelf and inherited from earlier paralic deposition

d. Fundamental problem of shelf sands is mechanism for getting sands away from shore systems and onto shelf; only mechanisms known today for significant transport away from shore are via turbidity currents and density underflows; these restricted to submarine canyons and further by-pass the shelf with deposition primarily on continental rise; many ancient sands interpreted as shelf sands; these include mainly mature, well sorted, sheet sands; study of many of these sands shows trends expected in a variety of paralic systems and not accumulation on continental shelves. Many thick paralic clastic deposits have been interpreted to represent neritic or shelf deposition because thin, intercalated fossiliferous beds of widespread extent contain fossils indicating up to 600 feet water depth; such sequences are actually paralic (deltaic, barrier, etc.) facies that were occasionally transgressed by shelf environments.

10. Mineral reservoirs: Terrigenous continental shelf systems and component facies are rarely productive of oil and gas, chiefly because of the paucity of such deposits in the geologic record. Many so-called "shelf" sands are highly productive, but these, in reality, belong to some other depositional system and are not a part of terrigenous shelf systems. Under conditions of carbonate deposition, shelf deposits are major oil and gas reservoirs. Their significance is largely restricted to providing a seal

to underlying sand facies. Such shelf sands as those currently being formed under high tidal influence in the North Sea would provide potential reservoirs, but ancient examples of such sand bodies have not been documented. With continued offshore drilling of post-drift continental shelf, such sands will doubtlessly be identified and should provide substantial reservoirs.

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Selected References

Allen, J. R. L. (1964) The Nigerian continental margin, bottom sediments, submarine morphology, and geologic evolution: Marine Geol., vol. 1, pp. 289-332.

Asquith, D. O. (1970) Depositional topography and major marine environments, Late Cretaceous, Wyoming: Amer. Assoc. Petrol. Geol. Bull., vol. 54, pp. 1184-1224.

Bagnold, R. A. (1946) Motion of waves in shallow water: interaction between waves and shallow bottoms: Proc. Royal Soc. (London) Ser. A, vol. 187, pp. 1-18.

---------- (1947) Sand movements by waves: some small scale experiments with sand of a very low density: Jour. Inst. Civil Engrs. (London) Paper 5554, pp. 447-469.

Barrell, J. (1906) Relative importance of continental, littoral, and marine sedimentation: Jour. Geol., vol. 14, pp. 420-457.

Boma, A. H., et al. (1968) Study of the continental shelf of the Gulf of Mexico: Texas A&M Tech. Rept. 68-2T.

Berthois, L. and LeCalvez, Y. (1959) Deuxieme contribution a l'etude de la sedimentation dans le Golfe de Gascogne: Paris, Rev. Travaux Institut Peches Maritimes, vol. 23.

Berzukov, P. L. (1960) Donnye otlozheniya Okhotskogo morya (bottom sediments of the Okhotsk Sea): Akad. Nauk SSSR Okeanologii Inst. Trudy, vol. 32, pp. 15-95.

Blanc, J. J. (1968) Sedimentary geology of the Mediterranean Sea, in H. Barnes (ed.); Oceanogr. Mar. Bio. Ann. Rev., vol. 6, pp. 377-454.

Boillot, G. (1964) Geologie de la Manche occidentale; fonds rocheux depots, Quaternaires, sediments actuels: Paris, Annales l'Institut Oceanographique, vol. 42, no. 1, 220 pp.

Bruckner, W. D. and Morgan, H. J. (1964) Heavy mineral distribution on the continental shelf off Accra, Ghana, West Africa, in Deltaic and shallow marine deposits, Amsterdam, (Elsevier) pp. 54-61.

Buffington, E. C. et al. (1967) From shore to abyss: Nearshore transport, slope deposition and erosion, canyon transport, and deep basin sedimentation (abs.): Amer. Assoc. Petrol. Geol. Bull., vol. 51, no. 3, pp. 456-457.

Carsey, J. B. (1950) Geology of Gulf coastal area and continental shelf: Amer. Assoc. Petrol. Geol. Bull., vol. 34, no. 3, pp. 361-385.

Chamberlain, T. K. (1964) Mass transport of sediment in heads of Scripps Submarine Canyon, California, in R. L. Miller (ed.), Papers in Marine Geology: Shepard Commemorative Volume, MacMillan, N. Y., pp. 42-63.

Colquhoun, D. J. (1969) Coastal plain terraces in the Carolinas and Georgia, U.S.A., in H. E. Wright (ed.), Quaternary Climate and Geology: Proc. INQUA, vol. 16, pp. 150-162.

Curray, J. R. (1960) Sediments and history of Holocene transgression, continental shelf, northwestern Gulf of Mexico, in Recent sediments, northwestern Gulf of Mexico: Amer. Assoc. Petrol. Geol., Tulsa, pp. 221-266.

---------- (1965) Late Quaternary history, continental shelves of the United States, in The Quaternary of the United States, Princeton Univ. Press, pp. 723-735.

---------- and Moore, D. G. (1964) Pleistocene deltaic progradation of the continental terrace, Costa de Nayarit, Mexico, in Van Andel and Shor (eds.), Marine Geology of the Gulf of California: Amer. Assoc. Petrol. Geol., Tulsa, pp. 193-215.

Davies, D. K. (1969) Shelf sedimentation: an example from the Jurassic of Britain: Jour. Sed. Petrol., vol. 39, pp. 1344-1370.

Dietz, R. S. (1964) Wave base, marine profile of equilibrium, wave built terraces: Reply: Geol. Soc. Amer. Bull., vol. 75, pp. 1275-1282.

----------, et al. (1964) Sediments and topography of the Alaskan shelves, in Papers in Marine Geology, p. 241, MacMillan Co., N. Y.

Dill, R. F. (1963) Contemporary erosion in the heads of submarine canyons: Geol. Soc. Amer. Sp. Pap. 76, p. 45.

---------- (1964) Sedimentation and erosion in Scripps Submarine Canyon, in R. L. Miller (ed.), Papers in Marine Geology: Shepard Commemorative Volume, MacMillan, N. Y.,pp. 23-41.

---------- (1967) Processes of submarine erosion in La Jolla fan-valley and their relationship to sediment-distribution patterns (abs.): Amer. Assoc. Petrol. Geol. Bull., vol. 51, p. 461.

Dingle, R. V. (1965) Sand waves in the North Sea mapped by continuous reflection profiling: Marine Geol., vol. 3, pp. 391-400.

Donahue, J. G., et al. (1966) Sediment size distribution profile on the continental shelf off New Jersey: Sedimentology, vol. 7, pp. 155-159.

Drake, D. E. and Gorsline, D. S. (1969) Dispersal of suspended sediment off southern California during and following the 1969 winter floods: Geol. Soc. Amer. Abst., part 7, p. 52.

Draper, L. (1966) Wave activity at the sea bed around northwestern Europe: Marine Geol., vol. 5, pp. 133-140.

Drever, J. I. (1969) Clay mineral formation and river water chemistry, Rio Ameca Basin, Mexico: Geol. Soc. Amer. Abst., part 7, p. 53.

Duncan, J. R. and Kulm, L. D. (1970) Mineralogy, provenance and dispersal history of late Quaternary deep-sea sands in Cascadia Basin and Blanco Fracture Zone: Jour. Sed. Petrol., vol. 40, pp. 874-887.

Eagleson, P. S., et al. (1958) The mechanics of the motion of discrete spherical bottom sediment particles due to shoaling waves: U. S. Army Beach Erosion Board Tech. Mem. 104, 41 pp.

Earley, C. F. and Goodell, H. G. (1968) The sediments of Card Sound, Florida: Jour. Sed. Petrol., vol. 38, pp. 985-999.

Emery, K. O. (1949) Topography and sediments of the Arctic Basin: Jour. Geol., vol. 57, pp. 512-521.

---------- (1959) The sea off southern California: Wiley, New York, 366 pp.

---------- (1964) Sediments of the Gulf of Agabe (Eilat), in Papers in Marine Geology, p. 257, MacMillan Co., N. Y. 531 pp.

---------- (1968) Relict sediments on continental shelves of the World: Amer. Assoc. Petrol. Geol. Bull., vol. 52, pp. 445-464.

---------- and Bentor, Y. K. (1960) The continental shelf of Israel: Israel Geol. Surv. Bull., vol. 26, pp. 24-41.

Ewing, M., et al. (1964) Sediment distribution in the oceans: the Argentine Basin: Jour. Geophys. Res., vol. 69, pp. 2003-2332.

---------- and Ewing, J. (1965) The sediments of the Argentine Basin: Anais de Acad. Brasileira de Ciencias, vol. 37, pp. 31-61.

Field, M. E. and Pilkey, O. H. (1969) Source and transportation of sediments on the Carolina continental rise: Geol. Soc. Amer. Abst., part 7, p. 64.

Fisk, H. N. (1956) Nearshore sediments of the continental shelf off Louisiana: Proc. of the 8th Tex. Conf. on soil mechanics and foundation engineering, Austin, Texas, Sept. 14-15, pp. 1-26.

Fleming, R. H. (1938) Tides and tidal currents in the Gulf of Panama: Jour. Marine Res., vol. 1, pp. 192-206.

Fuller, A. O. (1961) Size distribution characteristics of shallow marine sands from the Cape of Good Hope, South Africa: Jour. Sed. Petrol., vol. 31, pp. 256-261.

Garrison, L. E. (1970) Development of continental shelf south of New England: Amer. Assoc. Petrol. Geol. Bull., pp. 109-124.

---------- and McMaster, R. L. (1966) Sediments and geomorphology of the continental shelf off western New England: Marine Geol., vol. 4, pp. 273-289.

Gorshkova, T. I. (1957) Osadki Karskogo morya (Sediments of the Kara Sea): Vsesoygznogo Gidrobilolgickeskogo Obshchestva, Trudy, vol. 8, pp. 68-99.

Gorsline, D. S. (1963) Bottom sediments of the Atlantic shelf and slope off southern United States: Jour. Geol., vol. 71, pp. 422-440.

Goudell, H. G. (1967) The sediments and sedimentary geochemistry of the Southwestern Atlantic Shelf: Jour. Geol., vol. 75, pp. 665-692.

Gould, H. R. and Stewart, R. H. (1955) Continental terrace sediments in the northeastern Gulf of Mexico: S. E. P. M. Sp. Pub. 3, pp. 1-20.

Greenmann, N. N. and LeBlanc, R. J. (1956) Recent marine sediments and environments of the northwestern Gulf of Mexico: Amer. Assoc. Petrol. Geol. Bull., vol. 40, pp. 813-847.

Gross, M. G., et al. (1967) Continental shelf sediment, Northwestern United States: Jour. Sed. Petrol., vol. 37, pp. 790-795.

Hadley, M. L. (1964) The continental margin southwest of the English Channel: Deep Sea Res., vol. 11, pp. 767-779.

Hayes, M. O. (1965) Sedimentation on a semi-arid, wave dominated coast (South Texas): with emphasis on hurricane effects: Ph. D. Dissertation, Univ. of Texas, 385 pp.

---------- (1967a) Hurricanes as geologic agents: Case studies of hurricanes Carla, 1961, and Cindy, 1963: Texas. Bur. Econ. Geol. Rept. 61, 54 pp.

---------- (1967b) Relationship between coastal climate and bottom sediment type on the inner continental shelf: Marine Geol., vol. 5, pp. 111-132.

---------- and Scott, A. J. (1964) Environmental complexes, South Texas coast: Gulf Coast Assoc. Geol. Soc. Trans., vol. 14, pp. 237-240.

Heezen, B. C. and Johnson, G. L. (1969) Mediterranean undercurrent and micro-physiography west of Gibraltar: Bull. Inst. Oceanographique, vol. 67 (1382), 95 pp.

Holtedahl, H. (1955) On the Norwegian continental terrace, primarily outside Mre-Romsdal - its geomorphology and sediments: Bergen, Norway, Universitetet i Bergen Arbok, Naturvitenskapelig rekke, vol. 14, 209 pp.

Houbolt, J. J. H. C. (1968) Recent sediments in the southern Bight of the North Sea: Geol. en Mijnbouw, vol. 47 (4), pp. 245-273.

Hulseman, J. and Emery, K. O. (1961) Stratification in recent sediments of Santa Barbara Basin as controlled by organisms and water character: Jour. Geol., vol. 69, pp. 279-290.

Hyne, N. J. and Goodell, H. G. (1967) Origin of sediments and submarine geology of the inner continental shelf off Choctawatchee Bay, Florida: Marine Geol., vol. 5, pp. 299-313.

Imbrie, J. and Buchanan, H. (1965) Sedimentary structures in modern carbonate sands of the Bahamas, in Primary sedimentary structures, SEPM Spec. Pub. 12, pp. 149-172.

Inman, D. L. (1958) Environmental significance of oscillatory ripple marks: Eclogae Geol. Helv., vol. 51, pp. 522-523.

---------- and Chamberlain, T. K. (1955) Particle size distribution in nearshore sediments: S. E. P. M. Sp. Bull. No. 3, pp. 106-127.

---------- and Bagnold, R. A. (1963) Littoral processes, in Hill (ed.), The Sea, vol. 3, pp. 529-553.

Jacobs, M. B. and Ewing, M. (1969) Mineral sources and transport in waters of the Gulf of Mexico and Caribbean Sea, in Science, vol. 163, no. 3869, pp. 805-810.

James, N. P. (1966) Sediment distribution and dispersal patterns on Sable Island and Sable Island Bank: M. S. Thesis, Dalhousie Univ., Halifax, N. S., 253 pp.

Johnson, M. A. and Stride, A. H. (1969) Geological significance of North Sea sand transportation rates: Nature, vol. 224, pp. 1016-1017.

Jones, H. A. (1971) Late Cenozoic sedimentary forms on the northwest Australian continental shelf: Marine Geol., vol. 10, p. M20.

Jones, N. S., et al. (1965) The movement of sand waves on Warts Bank, Isle of Man: Marine Geol., vol. 3, pp. 329-336.

Jordan, G. F. (1962) Large submarine sand waves: Science, vol. 136, pp. 839-848.

---------- (1962) Submarine physiography of the U. S. continental margin: U. S. Coast and Geod. Surv. Bull., no. 18, 28 pp.

Keller, G. H. and Richards, A. F. (1967) Sediments of the Malacca Strait, southeast Asia: Jour. Sed. Petrol., vol. 37, pp. 102-127.

Klenova, M. V. (1960) Geologiya Barentsova morya (Geology of the Barents Sea): Moscow, Akad. Nauk SSSR, 365 p.

Kolp, O. (1966) The sediment of the western and southern area of the Baltic Sea and their representation (Die Sedimente der westlichen und sudlichen Ostsee and ihre Darstellung): Beitrage zur Meereskunde (East Berlin), no. 17/18, pp. 9-60.

Krause, D. C. (1964) Lithology and sedimentation in the southern continental borderland, in Papers in Marine Geology, p. 274, MacMillan Co., N. Y., 531 pp.

Lisitsin, A. P. (1966) Protessy sovremennogo osadkoobrazovaniya v Beringorom more (Processes of recent sedimentation in the Bering Sea): Moscow, Akad. Nauk SSSR, Izdatelstro "Nauka," 574 pp.

Lohse, E. A. (1952) Shallow marine sediments of the Rio Grande delta: Unpub. Ph. D. Dissertation, Univ. of Texas, 113 pp.

---------- (1955) Dynamic geology of the modern coastal region, Northwest Gulf of Mexico, in Finding Ancient Shorelines: S. E. P. M. Sp. Pub. No. 3, pp. 99-103.

Ludwick, J. C. (1964) Sediments in Northeastern Gulf of Mexico, in Papers in Marine Geology, p. 204, MacMillan Co., N. Y. 531 p.

McCave, I. N. (1971) Sand waves in the North Sea off the Coast of Holland: Marine Geol., vol. 10, no. 3, pp. 199-225.

McMaster, R. L. and Garrison, L. E. (1966) Mineralogy and origin of southern New England shelf sediments: Jour. Sed. Petrol., vol. 36, pp. 1131-1142.

Manheim, F. T., et al. (1970) Suspended matter in surface waters of the Atlantic Continental Margin from Cape Cod to the Florida Keys: Science, vol. 167, pp. 371-376.

Marlowe, J. I. (1968a) Unconsolidated marine sediments in Baffin Bay: Jour. Sed. Petrol., vol. 38, pp. 1065-1078.

---------- (1968b) Sedimentology of the Prince Gustaf Adolf Sea area: Dist. of Franklin, Geol. Surv. of Canada Paper 66-29, 83 pp.

Maxwell, W. G. H. and Swinchatt, J. P. (1970) Great Barrier Reef: regional variation in a terrigenous-carbonate province: Geol. Soc. Amer. Bull., vol. 81, pp. 691-724.

Meade, R. H. (1969) Landward transport of bottom sediments in estuaries of the Atlantic Coastal Plain: Jour. Sed. Petrol., vol. 39, pp. 222-234.

Miller, R. L. and Ziegler, J. M. (1964) A study of sediment distribution in the zone of shoaling waves over complicated topography, in Papers in Marine Geology, p. 133, MacMillan Co., N. Y., 531 p.

---------- and ---------- (1964) A study of the relation between dynamics and sediment pattern in the region of shoaling waves: Eclogae Geol. Helv., vol. 51, pp. 542-551.

Mollan, R. G., et al. (1970) Geologic framework of the continental shelf off northwestern Australia: Amer. Assoc. Petrol. Geol. Bull., vol. 54, pp. 583-600.

Moore, D. G. (1964) Acoustic-reflection reconnaissance of continental shelves: eastern Bering and Chukchi Seas, in Miller (ed.), Papers in Marine Geology: Shepard Comm. Volume, MacMillan, N. Y., pp. 319-362.

---------- and Curray, J. R. (1963) Sedimentary framework of continental terrace off Norfolk, Virginia, and Newport, Rhode Island: Amer. Assoc. Petrol. Geol. Bull., vol. 47, pp. 2051-2054.

Nagata, Y. (1961) Balance of the transport of sediment due to wave action in shoaling water, surf zone, and on foreshore: Records Oceanog. Works Japan, vol. 6, pp. 53-62.

Nasu, N. (1964) The provenance of the coarse sediments of the continental shelves and trench slopes off the Japanese Pacific Coast, in Miller (ed.), Papers in Marine Geology: Shepard Comm. Volume, pp. 65-101, MacMillan, N. Y.

Natland, M. L. (1967) New classification of water-laid clastic sediments (abst.): Amer. Assoc. Petrol. Geol. Bull., vol. 51, p. 476.

Nienaber, J. H. (1963) Shallow marine sediments offshore from the Brazos River, Texas: Publ. Inst. Marine Sci., Univ. of Texas, vol. 9, pp. 311-372.

Niino, H. and Emery, K. O. (1966) Continental shelf off northeastern Asia: Jour. Sed. Petrol., vol. 36, pp. 142-161.

Nota, D. J. G. (1958) Sediments of the western Guiana shelf: Meded. van de Landbouwhogschool te Wagnaningen, vol. 58, no. 2, p. 98.

Off, T. (1963) Rhythmic linear sand bodies caused by tidal currents: Amer. Assoc. Petrol. Geol. Bull., vol. 47, pp. 324-341.

Perkins, R. D. and Halsey, S. D. (1969) Organic erosion of Carolina shelf sediments: Geol. Soc. Amer. Abst., part 7, p. 172.

Pevear, D. R. (1969) Distribution of clays by currents on the shelf, slope and rise of the southeastern United States: Geol. Soc. Amer. Abst., part 7, p. 175.

Picard, M. D. and High, L. R., Jr. (1968) Shallow marine currents on the Early (?) Triassic Wyoming shelf: Jour. Sed. Petrol., vol. 38, pp. 411-424.

Pickett, T. E. and Ingram, R. L. (1969) The modern sediments of Pamlico Sound, North Carolina: Southeastern Geol., vol. 11, pp. 53-84.

Price, W. A. (1954) Dynamic environments - reconnaissance mapping, geologic, geomorphic - of the continental shelf of Gulf of Mexico: Gulf Coast Assoc. Geol. Soc. Trans., vol. 4, pp. 75-107.

Putnam, J. A., et al. (1949) The prediction of longshore currents: Trans. Am. Geophys. Union, vol. 30, pp. 337-345.

Rao, M. S. (1964) Some aspects of continental shelf sediments off the east coast of India: Marine Geol., vol. 1, pp. 59-87.

Reineck, H. E. (1963) Sedimentgefuge im Bereich der sudlichen Nordsee: Abh. Senckenbergischen Natur. Gesells., no. 505, pp. 1-138.

---------- (1967) Layered sediments of tidal flats, beaches, and shelf bottoms of the North Sea, in Lauff (ed.), Conference on Estuaries, pp. 191-206.

----------, Gutman, W. F., and Hertweck, G. (1967) Das Schlickgebiet sudlich Helgoland als Beispiel rezenter Schelfablagerung (Silt deposits south of Heligoland as an example of Recent shelf sedimentation): Senckenbergiana lethaea, vol. 48 (3/4), pp. 219-256.

Rex, R. W. (1964) Arctic Beaches, Barrow, Alaska, in Papers in Marine Geology, MacMillan Co., N. Y., p. 384, 531 p.

Rodolfo, K. S. (1969) Suspended sediments in surface Andaman sea waters off the Irrawaddy Delta, Northeastern Indian Ocean: Geol. Soc. Amer. Abst., part 7, p. 190.

Sanders, John E. (1965) Nearshore sands off southeast Virginia (abst.): Amer. Assoc. Petrol. Geol. Bull., vol. 49, no. 3, p. 357.

Seibold, E. (1963) Geological investigations of nearshore sand transport - examples of methods and problems from the Baltic and North Seas, in Sears (ed.), Progress in Oceanog., vol. 1, pp. 1-70.

Seilacher, A. (1964) Biogenic sedimentary structures, in Approaches to paleoecology: John Wiley, New York, pp. 296-316.

Shepard, F. P. (1951) Mass movement in submarine canyon heads: Trans. Am. Geophys. Union, vol. 32, pp. 405-418.

----------, et al. (1941) Rip currents, a process of geologic importance: Jour. Geol., vol. 49, pp. 337-369.

---------- and Inman, D. L. (1953) Aerial and seasonal variations in beach and nearshore sediments at La Jolla, Calif.: U. S. Army Beach Erosion Board, Tech. Mem. 39, 82 p.

Smith, J. D. (1969) Geomorphology of a sand ridge: Jour. Geol., vol. 76, pp. 39-55.

Stetson, H. C. (1939) Summary of sedimentary conditions on the continental shelf off the east coast of the United States, in Recent Marine Sediments: Amer. Assoc. Petrol. Geol., Tulsa, pp. 230-244.

Stone, I. C. and Siegel, F. R. (1969) Distribution and provenance of minerals from continental shelf sediments off the South Carolina Coast: Jour. Sed. Petrol., vol. 39, pp. 276-297.

Stride, A. H. (1963) Current swept sea floors near the southern half of Great Britain: Quart Jour. Geol. Soc. London, vol. 119, pp. 175-199.

Swift, D. (1968) Mesozoic versus modern sedimentation of the Carolina coast, and the problem of the graded shelf: Southeastern Section, Geol. Soc. Ann. Meeting Program, p. 68.

Tanner, W. F., et al. (1963) Low-energy coast near Cape Romano, Florida: Jour. Sed. Petrol., vol. 33, pp. 713-722.

Uchupi, E. (1968) Atlantic continental shelf and slope of the United States - physiography: U. S. Geol. Surv. Prof. Pap. 529-C, 30 p.

---------- (1969) Morphology of continental margin off southeastern Florida (abst.): Southeastern Geol., vol. 11, pp. 129-134.

Van Andel, T. H. (1954) Recent sediments of the Gulf of Paria, in Reports of the Orinoco Shelf Expedition, vol. 1, Kon. Nedrl., Akad. Wetensch. Verh., vol. 20, 238 pp.

---------- (1960) Sources and dispersion of Holocene sediments, northern Gulf of Mexico: Amer. Assoc. Petrol. Geol., Tulsa, pp. 34-55.

---------- (1964) Recent marine sediments of Gulf of California, in Van Andel and Shor (eds.), Marine Geology of the Gulf of California: Amer. Assoc. Petrol. Geol., Tulsa, pp. 216-310.

---------- (1965) Morphology and sediments of the Sahul shelf, northwestern Australia: New York Acad. Sci. Trans., ser. 2, vol. 28, pp. 81-89.

---------- and Poole, D. M. (1960) Sources of recent sediments in the northern Gulf of Mexico: Jour. Sed. Petrol., vol. 30, pp. 91-122.

---------- and Sachs, P. L. (1964) Sedimentation in the Gulf of Paria during the Holocene transgression: a subsurface reflection study: Jour. Marine Research, vol. 22, pp. 30-50.

---------- and Veevers, J. J. (1967) Morphology and sediments of the Timor Sea: Australian Dept. Natural Development, Bur. Min. Resources, Geology and Geophysics, Bull. 83, 173 pp.

Van der Lingen, G. J. and Andrews, P. B. (1968) Grain size parameters and sedimentary structures of a last interglacial marine sand body, near Westport, New Zealand: New Zealand Jour. of Marine and Freshwater Res., vol. 2, pp. 447-471.

Van Straaten, L. M. J. U. (1959) Minor structures of some recent littoral and neritic sediments: Geol. en Mijnbouw, vol. 21, pp. 197-216.

---------- (1965) Sedimentation in the northwestern part of the Adriatic Sea, in Submarine geology and geophysics, London, Butterworths, pp. 143-162.

Veenstra, H. J. (1969) Gravels of the southern North Sea: Marine Geol., vol. 7, pp. 449-464.

Vernon, J. W. (1966) Coastal sediment circulatory system (abst.): Geol. Soc. Amer. Pap. 87, pp. 178-179.

White, S. M. (1970) Mineralogy and geochemistry of continental shelf sediments off the Washington-Oregon coast: Jour. Sed. Petrol., vol. 40, pp. 38-54.

SLOPE AND ABYSSAL SYSTEMS -- Summary

1. Occur along continental margins, deep lakes, and cratonic basins; modern studies handicapped by post-Pleistocene sea-level rise (deltas not actively prograding shelf, destruction process presently dominates slopes); difficult to obtain representative sequences for study (deeply buried in most ancient basins or in geosynclinal belts with structural complexity)

2. General characteristics of modern slopes

   a. Physiography (margin, upper, middle and lower slope): gradient, degree of dissection, types and rates of sediment input important
   b. Primary slope origin: progradation, slumping and gravity sliding, tectonics, faulting, damming of outer margins (salt diapirs or faults), downwarping of continental margins, rifting, sea-floor spreading
   c. Secondary modification: erosion (submarine canyons), progradation by fans and deltas, on-lap of rises, carbonate build-up, construction versus destruction (contemporaneous and temporally distinct)

3. Depositional processes and slope sediments

   a. Traction versus suspension transport
   b. Mass gravity movement (fluxoturbidites, pebbly mudstones, wildflysch)
   c. Turbidity flow and turbidites (density or hyperpycnal flow, graded beds, experimental versus observed flow, flysch and tectonics, the Bouma sequence)
   d. Grain and shear flow, bottom-hugging traction flow
   e. Suspension and pelitic-pelagic deposits
   f. Contour or geostrophic currents and contourites
   g. Cloudy (nepheloid) suspension currents
   h. Bioturbation
   i. Summary: mass gravity movement: fluxoturbidites--turbidity and traction transport: turbidites and pelites--nepheloid clouds and other suspensions: pelagites--slope and abyssal deposits modified by geostrophic currents

4. Modern slope environments: their processes and sediments

Modern slopes are principally undergoing destruction. For this reason, they are not necessarily valid models for many ancient systems.

a. Shelf break, upper, and mid slope: erosion and sediment by-pass dominant; extensive channels and canyons; mass gravity transport common (slumps, slides, mud and debris flow); bioturbation; fluxoturbidites dominant; restricted lateral persistency of individual sedimentary units; downslope directional features consistent

b. Lower and distal slope: deposition dominant; upper and mid-slope channels and canyons bifurcate downslope into submarine fan distributaries; moderate bioturbation; turbidity or density flow dominant; some fluxoturbidites and amalgamated beds in proximal areas; fans display generally predictable downfan changes in Bouma sequence; fans grade distally into pelagic basinal or abyssal deposits; individual sedimentary units thin, sheetlike; downslope directional indicators variable; when net progradation not maintained, these environments on-lap as continental or basinal rise

c. Continental rise: similar in most respects to lower and distal slope environments and deposits; rise sediments are deposited in lower and distal environments under a waning or diminishing sediment supply resulting in upslope migration of environments and onlap of depositional units; related to a sediment-starved or destructional episode

d. Basin floor or abyssal plain: dominance of pelagic deposition, starved basin, siliceous sediments, organic content concentrated by slow suspension deposition, minimum bioturbation

5. The submarine fan: a fundamental depositional element

Principal processes, modern occurrence and distribution, fan surface (channels, levees, fan plain, distal fringe); internal depositional units (Bouma sequence, flow regime, spatial variations); downfan (proximal-medial-distal) variations in process, textures, sedimentary structures, facies; shifting and transient character of individual fans, fans as components of submarine fan-cones and slope systems

6. Depositional phases of slope development (based on Modern and ancient analogues)

a. Constructional phase: dominant processes on slope result in significant sustained net progradation or out-building of slope system into basin; coincident with maximum upbuilding (regression) on adjacent shelf by dip-fed deltas and fan-deltas; period of sustained direct supply of slope by paralic deposition near shelf-edge, followed by gravity transport in slope-distributary system; transported delta sediment (suspended sediment via hyperpycnal flow; traction transport via fresh-water wedge) does not pass directly into slope transport system but passes through finite period as deltaic or marine reworked deposits before erosion and transportation via mass movement or density (hyperpycnal) flow

b. Destructional phase: dominant processes on slope result in significant redistribution of slope sediments and erosion of paralic sediments along shelf-edge in absence of sustained, direct sediment supply by paralic systems; diminished progradation with ultimate development of on-lapping continental rise; dissection of upper slope and outer shelf with large submarine canyons possible; significant periods of destruction coincident with nondeposition of paralic sediments and extensive shelf transgression of paralic environments; may be related to glacial sea level rise or major avulsion of drainage system in the region

c. Temporal and geographic relationship of depositional phases: slope construction occurs persistently only when supplied by paralic systems (i. e., delta and fan delta) at point sources along a shelf-edge; a destructional phase develops locally when sustained sediment supply shifts to another position along the shelf-edge; at any site along the basin margin, constructional and destructional slope deposition will alternate as paralic supply of sediment shifts from position to position on the shelf; construction and destruction may occur contemporaneously but at different geographic locations along a basin margin; only when sea level rise or a major shift in paralic sediment supply occurs will slope destruction occur simultaneously along an entire basin margin

7. Compound fan-cones and fan-wedges (based on Modern and ancient analogues)

a. Compound fan-cones: The fundamental depositional element in slope systems is the submarine fan, but slopes prograde by outbuilding of compound fan-cones composed of many individual submarine fan deposits. Fed by one or more paralic sources on the shelf (i. e., major delta system with several lobes) the compound fan-cone is a large basinward bulge of slope sediments that defines a principal physiographic feature sloping basinward from one or more feeder channels or slope canyons. The fan-cone is analogous to a major delta with several lobes (e. g., individual fans) that has a finite history of construction, destruction, reactivation, and eventual abandonment. The compound fan-cone is the fundamental constructional element in slope systems; it is defined by its component fans and their individual facies.

Progradation (construction) and reworking (destruction) can occur at the same time on different fans within a compound fan-cone, but as long as sediment is being supplied consistently to the compound fan, construction dominates; abandonment of the cone either temporarily or permanently results in dominant destruction; terminal abandonment results in destruction leading to development of significant rise deposits.

b. Fan-wedges: Internally, the stratigraphic and sedimentary character of a compound fan-cone will reflect the nature and relative dominance of constructional and destructional episodes. Any cross section through a fan-cone parallel to paleoslope will display one or more wedgelike stratigraphic units. Depending on sufficient control, these fan-wedges can be recognized and mapped using seismic techniques and conventional subsurface methods. Thickness, areal extent, and external geometry of individual slope fan-wedges (and the compound fan-cone) is variable and is dependent upon the tectonic and sedimentary style of the basin.

The fan-wedge may contain sedimentary units ranging basinward from proximal facies dominated by fluxoturbidites deposited in upper and mid-slope environments to distal facies dominated by individual turbidite fans. The fan-wedge displays a facies tract that represents transport and deposition linking paralic systems with basinal or abyssal systems. The fan-wedge is, therefore, composed of component facies defined by fossils, textures, vertical sequences, and sedimentary structures. Externally, the fan-wedge can be classified into several principal types:

1. Off-lap fan-wedge: develops from compound fan-cone deposition during active progradation in a basin with minimum tectonic subsidence. Relatively complete facies tract preserved; proximal wedge with minimum fluxoturbidites; wedge dominated by turbidity deposits; defined stratigraphically and seismically by large "foreset" units with 3 to 5 degrees basinward slope; common in cratonic basins and along mid-plate continental margins
2. Up-lap fan-wedge: develops from compound fan-cone deposition within a basin exhibiting significant fault-controlled subsidence. Proximal wedge deposits dominated by fluxoturbidites; defined seismically and stratigraphically by minimum out-building and maximum up-building or stacking of wedges due to rapid subsidence rates; wedges commonly less inclined basinward than off-lap wedges; common along tectonically active continental and basinal margins or plate-boundaries; may be modified by post-depositional tectonism
3. On-lap or rise fan-wedge: develops during a significant period of fan-cone destruction; results in shelfward migration of fan environments with resulting continental or basinal rise deposition on-lapping constructional cone; rise wedges commonly occur following terminal abandonment of a fan-cone; stratigraphically and seismically the on-lap rise wedge displays a progressive shelfward on-lap of older wedges; the wedge may grade upward into carbonate deposits as sediment-starved shelf becomes a carbonate system

8. Genetic slope systems (continental margins and cratonic basins)

    It is important to remember that most Modern slopes are in a destructional phase induced by recent rise in sea level. Consequently, there are few Modern examples of paralic sediment being supplied to outer and shelf-edge sites. Thus, valid slope models must be based on both Modern and ancient analogues

    a. Fan-fed slope systems: typically occur in fault-bounded basins or along plate margins with significant tectonic activity; nearby elevated source of sediments; compound fan-cones fed by fan-deltas (high gradient, coarse-grained bedload braided streams); multiple fan-delta supply along basin margin; narrow shelf precludes construction of broad wedge of paralic sediments; fan-related slope deposits contain abundant gravels, slump blocks, fluxoturbidites, amalgamated beds, flutes, and sand-rich flysch in proximal fan-wedge; mid-slope and distal slope deposits difficult to distinguish from distal delta-fed slope systems; system is characterized by dominance of up-lap fan-wedges
        1. Continental margins: Mio-Pliocene of California, Modern-Holocene of California, Moderan Yallahs basin of Jamaica
        2. Mobile basin (flysch troughs and foreland basins): Marathon, Ouachita, Alps
        3. Yoked basins (cratonic basins with bounding faults): Ancestral Rockies with granite wash

    b. Delta-fed slope systems: typically occur in basins with minimum tectonic activity except for gradual subsidence; distant- and/or low-relief source area; large drainage basins; compound fan-cones fed by high-constructive and tide-dominated deltas; short periods of continuous sediment supply followed by long periods of delta abandonment and corresponding slope destruction; associated with wide shelves and extensive paralic systems; slope systems high in mud and organics, low in sand, rare gravels, few fluxoturbidites in proximal fan-wedge; distal slope deposits similar to other systems; system is characterized by off-lap fan wedges
        1. Continental margins: Gulf of Mexico; tide-dominated deltas of southeastern Asia
        2. Cratonic basins such as Midland basin, Cretaceous of U. S. Western Interior, Spanish Carboniferous, Lower Mississippian of Illinois Basin

   c. Sediment-starved slope systems: related to tectonically or climatically diverted drainage, eustatic sea-level rise, areas of prolonged strike deposition without outbuilding to outer shelf; biogenic shelf deposits with compound fan-cones essentially destructive; common limestone turbidite fans or aprons; some slumping and erosion of shelf edge and common development of submarine canyons; system is characterized by dominance of on-lap or rise fan wedges

9. Stratigraphic and seismic profiles of various slope systems; stratigraphic identification of fan-fed, delta-fed, and sediment-starved systems

10. Role of slope sediments in basin-filling; relationship to plate tectonics and geosynclinal theory

11. Mineral reservoirs: submarine, slope, channel, and fan sand deposits provide significant reservoirs in many basins of the world; updip pinchout of slope sands into marine muds provides excellent stratigraphic traps. The occurrence of salt-diapir slopes, slopes with extensive growth faulting, and abundant gravity slumping and sliding provide potential structural traps. Such reservoirs are being encountered increasingly as deeper drilling proceeds in established basins. Nearly all sedimentary basins should have some sort of slope development.

SLOPE AND ABYSSAL SYSTEMS

Selected References

Adams, J. E., *et al.* (1951) Starved Pennsylvanian Midland Basin: Bull. Amer. Assoc. Petrol. Geol., vol. 35, pp. 2600-2607.

Andel, Tj.H. van, and Komar, P. D. (1969) Ponded sediments of the Mid-Atlantic Ridge between 22° and 23° North latitude: Bull. Geol. Soc. Amer., vol. 80, pp. 1163-1190.

Bartow, J. A. (1966) Deep submarine channel in Upper Miocene, Orange County, California: Jour. Sed. Petrology, vol. 36, pp. 700-705.

Bell, H. S. (1942) Density currents as agents for transporting sediments: Jour. Geology, vol. 50, pp. 512-547.

Benest, H. (1899) Submarine gullies, river outlets, and fresh-water escapes beneath sea level: Jour. Geology, vol. 14, pp. 394-413.

Bouma, A. H. (1962) Sedimentology of some flysch deposits; a graphic approach to facies interpretation: **Elsevier, Amsterdam** 168 pp.

------- (1964) Ancient and recent turbidites: Geol. en Mijnbouw, 43e Jaargang, pp. 375-379.

------- and Brouwer, A. (eds.) (1964) Turbidites: Elsevier Pub. Co., Amsterdam, 264 pp.

Bramlette, M. N. and Bradley, W. H. (1940) Geology and biology of North Atlantic deep-sea cores, Part I: U. S. Geol. Survey Prof. Paper 196-A, pp. 1-34.

Buffington, E. C. (1952) Submarine "natural levees": Jour. Geology, vol. 60, pp. 473-479.

------- (1961) Experimental turbidity currents on the sea flood: Bull. Amer. Assoc. Petrol. Geol., vol. 45, pp. 1392-1400.

------- and Moore, D. G. (1963) Geophysical evidence on the origin of gullied submarine slopes, San Clemente, Calif.: Jour. Geology, vol. 71, no. 3, pp. 356-370.

Carlson, P. R. and Nelson, C. H. (1969) Sediments and sedimentary structures of the Astoria Submarine Canyon-Fan System, Northeast Pacific: Jour. Sed. Petrology, vol. 39, pp. 1269-1282.

Chamberlin, T. C. (1914) Foreset beds and slope deposits: Jour. Geology, vol. 22, pp. 268-274.

Conolly, J. R. and Ewing, M. (1967) Sedimentation in the Puerto Rico Trench: Jour. Sed. Petrology, vol. 37, pp. 44-59.

Conrey, B. L. (1967) Early Pliocene sedimentary history of the Los Angeles Basin, California: Calif. Div. Mines and Geol. Spec. Rept. 93, 63 pp.

Cotton, C. A. (1918) Conditions of deposition on the continental shelf and slope: Jour. Geology, vol. 26, pp. 135-160.

Craig, G. Y. and Walton, E. K. (1962) Sedimentary structures and palaeocurrent directions from Silurian rocks of Kirkcudbrightshire: Trans. Edinburgh Geol. Soc., vol. 19, pp. 100-119.

Crowell, J. C. (1957) Origin of pebbly mudstones: Bull. Geol. Soc. Amer., vol. 68, pp. 993-1010.

-------, et al. (1966) Deep-water sedimentary structures, Pliocene Pico Formation, Santa Paula Creek, Ventura Basin, California: Calif. Div. Mines and Geology Spec. Rept. 89, 40 pp.

Curray, J. R. (1966) Geologic structure on the continental margin from subbottom profiles, northern and central Calif.: Geol. of Northern Calif., Calif. Div. Mines and Geology Bull. 190, pp. 337-342.

------- and Moore, D. G. (1964) Pleistocene deltaic progradation of continental terrence, Costa De Nayarit, Mexico, in Symposium on Marine Geology of the Gulf of California: Memoir 3 Amer. Assoc. Petrol. Geol. (T. H. van Ander and G. G. Shor, Jr., eds.), pp. 193-215.

------- and ------- (1971) Growth of the Bengal Deep-Sea Fan and denudation of the Himalayas: Bull. Geol. Soc. Amer., vol. 82, pp. 563-572.

-------, -------, Belderson, R. H., and Stride, A. H. (1966) Continental margin of western Europe: slope progradation and erosion: Science, vol. 154, pp. 265-266.

Daly, R. A. (1936) Origin of submarine canyons: Amer. Jour. Sci., vol. 31, pp. 401-420.

Dickas, A. B. and Payne, J. L. (1967) Upper Paleocene buried channel in Sacramento Valley, California: Bull. Amer. Assoc. Petrol. Geol., vol. 51, pp. 873-882.

Dietz, R. S. (1952) Geomorphic evolution of continental terrace (continental shelf and slope): Bull. Amer. Assoc. Petrol. Geol., vol. 36, pp. 1802-1819.

------- (1953) Possible deep-sea turbidity-current channels in the Indian Ocean: Bull. Geol. Soc. Amer., vol. 64, pp. 375-378.

------- (1963) Collapsing continental rises: an actualistic concept of geosynclines and mountain building: Jour. Geology, vol. 71, pp. 314-333.

------- and Holden, J. C. (1966) Deep sea deposits in but not on the continents: Bull. Amer. Assoc. Petrol. Geol., vol. 50, pp. 351-362.

------- and Menard, H. W. (1951) Origin of abrupt changes in slope at continental shelf margin: Bull. Amer. Assoc. Petrol. Geol., vol. 35, pp. 1994-2016.

Dill, R. F. (1969) Earthquake effects on fill of Scripps submarine canyon: Bull. Geol. Soc. Amer., vol. 80, pp. 321-328.

-------, Dietz, R. S., and Steward, H. B. (1954) Deep-sea channels and delta of the Monterey submarine canyon (California): Bull. Geol. Soc. Amer., vol. 65, pp. 191-193.

Dott, R. H., Jr. (1963) Dynamics of subaqueous gravity depositional processes: Bull. Amer. Assoc. Petrol. Geol., vol. 47, pp. 104-129.

Dzulynski, S. and Kotlarczyk, J. (1962) On load-casted ripples: Ann. Soc. Geol. Pologne, vol. 32, pp. 149-159.

------- and Radomski, A. (1956) Clastic dikes in the Carpathian flysch: Ann. Soc. Geol. Pologne, vol. 26 (3), pp. 225-264.

------- and Sanders, J. E. (1962) Current marks on firm mud bottoms: Trans. Conn. Acad. Arts Sci., vol. 42, pp. 57-96.

------- and Walton, E. K. (1965) Sedimentary features of flysch and greywackes, Developments in sedimentology 7,: Elsevier Pub. Co., Amsterdam, 274 pp.

-------,et al. (1959) Turbidites in flysche of the polish Carpathian Mountains: Bull. Geol. Soc. Amer., vol. 70, pp. 1089-1118.

Einsele, G. (1963) Uber Art und Richtungder Sedimentation un klastischen rheinischen Oberdevon (Famenne): Abhandl. Hess. Landesamtes Bodenforsch., vol. 43, pp. 1-60.

Elmendorf, C. H. and H. C. Heezen (1957) Oceanographic information for engineering submarine cable systems: The Bell System Tech. Jour., vol. 36, pp. 1047-1093.

Emery, K. O. (1950) A suggested origin of continental slopes and of submarine canyons: Geol. Mag., vol. 87, pp. 102-104.

------- (1960) Basin plains and aprons off southern California: Jour. Geology, vol. 68, pp. 464-479.

------- (1965) Characteristics of continental shelves and slopes: Bull. Amer. Assoc. Petrol. Geol., vol. 49, pp. 1379-1384.

------- (1968) Shallow structure of continental shelves and slopes: Southeastern Geol., vol. 9, pp. 173-194.

------- (1970) Continental margins of the world, in The Geology of the East Atlantic Continental Margin: Part 1, General and Economic Papers, F. M. Delany, ed., Rept. No. 70/13, Natural Environment Research Council, Institute of Geol. Sci., pp. 3-29.

------- and Ross, D. A. (1968) Topography and sediments of a small area of the continental slope south of Martha's Vineyard: Deep-Sea Research, vol. 15, pp. 415-422.

-------, et al. (1970) Continental rise off eastern North America: Bull. Amer. Assoc. Petrol. Geol., vol. 54, pp. 44-108.

Enos, P. (1969) Anatomy of a flysch: Jour. Sed. Petrology, vol. 39, pp. 680-723.

Ericson, D. B., Ewing, M., Wollin G., and Heezen, B. C. (1961) Atlantic deep-sea sediment cores: Bull. Geol. Soc. Amer., vol. 72, pp. 193-286.

Ewing, M., and Heezen, B.C. (1952) Turbidity currents and sediments in the North Atlantic: Bull. Amer. Assoc. Petrol. Geol., vol.36, pp. 489-512.

Ewing, M. and Ewing, J. (1965) Distribution of sediments in the world ocean (abs.): Bull. Amer. Assoc. Petrol. Geol., vol. 49, p. 339.

------ and Thorndike, E. M. (1965) Suspended matter in deep ocean waters: Science, vol. 147, no. 3663, pp. 1291-1294.

-------, et al. (1964) Sediment distribution in the oceans: Mid-Atlantic Ridge: Bull. Geol. Soc. Amer., vol. 75, pp. 17-36.

Forel, F. A. (1885) Les ravins sous-lacustre des fleuves glaciaires: C. R. Acad. Sci., Paris, vol. 101, pp. 725-728.

Gorsline, D. S. (1970) Submarine canyons: An introduction: Marine Geology, vol. 8, pp. 183-186.

Gould, H. R. (1951) Some quantitative aspects of Lake Mead turbidity currents, in Turbidity Currents and the Transportation of Coarse Sediment to Deep Water: Soc. Econ. Pal. Min. Spec. Pub. No. 2, pp. 34-52.

Griggs, G. B. and Kulm, L. D. (1970) Sedimentation in Cascadia Deep-Sea Channel: Bull. Geol. Soc. Amer., vol. 81, no. 5, pp. 1361-1384.

Grover, N. C., and Howard, C. S. (1938) The passage of turbid water through Lake Mead: Trans. Amer. Soc. Civil Engrs., vol. 103, pp. 720-790.

Hamilton, E. L. (1967) Marine geology of abyssal plains in the Gulf of Alaska? Jour. Geophys. Res., vol. 72, pp. 4189-4213.

Hand, B. M., and Emery, K. O. (1964) Turbidites and topography of north end of San Diego trough, California: Jour. Geology, vol. 72, pp. 526-542.

Hedberg, H. D. (1970) Continental margins from the viewpoint of the petroleum geologist: Bull. Amer. Assoc. Petrol. Geol., vol. 54, pp. 3-43.

Heezen, B. C. (1959) Dynamic processes of abyssal sedimentation: erosion, transportation and redeposition on the deep-sea floor: Geophys. Jour., vol. 2, pp. 142-163.

------- (1966) Shaping of the continental rise by deep geostrophic contour currents: Science (22 April, 1966), vol. 152, no. 3721.

------- and Drake, C. L. (1964) Grand Banks Slump: Bull. Amer. Assoc. Petrol. Geol., vol. 48, pp. 221-233.

------- and Ewing, M. (1952) Turbidity currents and slumps, and the 1929 Grand Banks earthquake: Amer. Jour. Sci., vol. 250, pp. 849-873.

------- and ------- (1955) Orleansville earthquake and turbidity currents: Bull. Amer. Assoc. Petrol. Geol., vol. 39, pp. 2505-2514.

------- and Tharp, M. (1959) Physiographic diagram, Atlantic Ocean (Sheet 1), Geol. Soc. Amer. Spec. Paper 65.

------- et al. (1964) Congo submarine canyon: Bull. Amer. Assoc. Petrol. Geol., vol. 48, pp. 1126-1149.

Hopkins, D. (1964) The Foynes Series: Namurian Turbidites in Western Ireland: Thesis, Univ. of Reading, 180 pp.

Hoskins, H. (1967) Seismic observations on the Atlantic-continental shelf, slope, and rise southeast of New England: Jour. Geology, vol. 75, pp. 598-611.

Huang, T. and Goodell, H. G. (1970) Sediments and sedimentary processes of eastern Mississippi Cone, Gulf of Mexico: Bull. Amer. Assoc. Petrol. Geol., vol. 54, pp. 2070-2100.

Hubert, J. F. (1964) Textural evidence for deposition of many western North Atlantic deep-sea sands and silts by ocean-bottom currents rather than turbidity currents: Jour. Geology, vol. 72, pp. 757-785.

------- (1967) Sedimentology of Prealpine Flysch sequences, Switzerland: Jour. Sed. Petrology, vol. 37, pp. 885-907.

Hunkins, K., et al. (1969) Nepheloid layers and bottom currents in the Arctic Ocean: Jour. Geophys. Res., vol. 74, p. 6995.

Jackson, W. E. (1964) Depositional topography and cyclic deposition in West-central Texas: Bull. Amer. Assoc. Petrol. Geol., vol. 48, pp. 317-328.

Kelling, G. and Stanley, D. J. (1970) Morphology and structure of Wilmington and Baltimore submarine canyons, Eastern United States: Jour. Geology, vol. 78, no. 6, pp. 637-660.

------- and Walton, E. K. (1957) Load-cast structures: their relationship to upper surface structures and their mode of formation: Geol. Mag., vol. 94, pp. 481-490.

Krause, D. C., et al. (1970) Turbidity currents and cable breaks in the western New Britain Trench: Bull. Geol. Soc. Amer., vol. 81, pp. 2153-2160.

Kuenen, Ph. H. (1938) Density currents in connection with the problem of submarine canyons: Geol. Mag., vol. 75, pp. 241-249.

------- (1947) Two problems of marine geology: atolls and canyons: Verh. Kon. Nederl. Akad. Wetensch. Amsterdam, Afd. Nat. Dl. 57, pp. 92-95.

------- (1958) Problems concerning source and transportation of flysch sediments: Geol. en Mijn., vol. 20, pp. 329-339.

------- (1964) Deep-sea sands and ancient turbidites, in Turbidites: Elsevier, Developments in Sedimentology, 3, pp. 3-33.

------- (1967) Emplacement of flysch-type sand beds: Sedimentology, vol. 9, pp. 203-243

Laughton, A. S. (1968) New evidence of erosion on the deep ocean floor: Deep-Sea Res., vol. 15, pp. 21-30.

Lovell, J. P. B. (1969) Tyee Formation: a study of proximality in turbidites: Jour. Sed. Petrology, vol. 39, pp. 935-953.

------- (1969) Tyee Formation: undeformed turbidites and their lateral equivalents: Bull. Geol. Soc. Amer., vol. 80, pp. 9-22.

Martin, B. D. (1963) Rosedale channel -- evidence for late Miocene submarine erosion in Great Valley of California: Bull. Amer. Assoc. Petrol. Geol., vol. 47, pp. 441-456.

------- and Emery, K. O. (1967) Geology of Monterey Canyon, California: Bull. Amer. Assoc. Petrol. Geol., vol. 51, pp. 2281-2304.

Maury, M. F. (1855) Physical Geography of the Sea: Harpers, New York, 389 pp.

McBride, E. F. (1968) Sedimentary petrology and history of the Haymond Formation (Pennsylvanian), Marathon Basin, Texas: Univ. Texas, Bur. Econ. Geology Rept. Inv. 57, 101 pp.

------- (1969) Stratigraphy and sedimentology of the Woods Hollow Formation (Middle Ordovician), Trans-Pecos, Texas: Bull. Geol. Soc. Amer., vol. 80, pp. 2287-2302.

------- (1970) Stratigraphy and origin of Maravillas Formation (Upper Ordovician) West Texas: Bull. Amer. Assoc. Petrol. Geol., vol. 54, pp. 1719-1745.

------ and Kimberly, J. E. (1963) Sedimentology of Smithwick Shale (Pennsylvanian), Eastern Llano Region, Texas: Bull. Amer. Assoc. Petrol. Geol., vol. 47, pp. 1840-1854.

McMaster, R. L. and Lachance, T. P. (1968) Seismic Reflectively Studies on northwestern African Continental Shelf: Strait of Gibraltar to Mauritania: Bull. Amer. Assoc. Petrol. Geol., vol. 52, pp. 2387-2395.

Menard, H. W. (1955) Deep-sea channels, topography, and sedimentation: Bull. Amer. Assoc. Petrol. Geol., vol. 49, pp. 236-255.

------- (1964) Marine geology of the Pacific: McGraw-Hill Book Co., 271 pp.

------- and Ludwick, J. C. (1951) Application of Hydraulics to the study of Marine Turbidity currents, in Turbidity Currents and the Transportation of Coarse sediment to deep water: Soc. Econ. Pal. Min. Spec. Pub. No. 2, pp. 2-13.

Middleton, G. V.(1966a)Experiments on density and turbidity currents: I. Motion of the head: Canadian Jour. Earth Sci., vol. 3, pp. 523-546.

-----(1966b) Experiments on density and turbidity currents: II. Uniform flow of density currents: Canadian Jour. Earth Sci., vol. 3, pp. 627-637.

------- (1967) Experiments on density and turbidity currents: III. Deposition of Sediment: Canadian Jour. Earth Sci., vol. 4, pp. 475-505.

Miller, R. L. (ed.) (1964) Shepard Commemorative Volume, in Papers in Marine Geology: MacMillan Co., New York, 531 pp.

Milne, J. (1897) Suboceanic changes: Jour. Geog., vol. 10, pp. 129-146; 259-289.

Moore, D. G. (1960) Acoustic-reflection studies of the continental shelf and slope off southern California: Bull. Geol. Soc. Amer., vol. 71, pp. 1121-1136.

------- and Curray, J. R. (1963) Sedimentary framework of continental terrace off Norfolk, Virginia and Newport, Rhode Island: Bull. Amer. Assoc. Petrol. Geol., vol. 47, pp. 2051-2054.

Moore, T. C., et al. (1970) Large submarine slide off northeastern continental margin of Brazil: Bull. Amer. Assoc. Petrol. Geol., vol. 54, pp. 125-128.

Morris, R. C. (1971) Stratigraphy and sedimentology of Jackfork Group, Arkansas: Bull. Amer. Assoc. Petrol. Geol., vol. 55, pp. 387-402.

------- (1971) Classification and interpretation of disturbed bedding types in Jackfork Flysch rocks (Upper Mississippian), Ouachita Mountains, Arkansas: Jour. Sed. Petrology, vol. 41, pp. 410-424.

Murphy, M. A. and Schlanger, S. O. (1962) Sedimentary structures in Ilhas and Sao Sebastiao Formations (Cretaceous), Reconcavo Basin, Brazil: Amer. Assoc. Petrol. Geol. Bull., vol. 46, pp. 457-477.

Natland, M. L. and Kuenen, Ph.H. (1951) Sedimentary history of the Ventura Basin, California, and the action of turbidity currents: S.E.P.M. Spec. Pub. no. 2, pp. 76-107.

Nelson, C. H., et al. (1970) Development of the Astoria canyon-fan physiography and comparison with similar systems: Marine Geol., vol. 8, pp. 259-291.

Neumann, A. C. and Ball, M. M. (1970) Submersible observations in the straits of Florida: Geology and bottom currents: Geol. Soc. Amer. Bull., vol. 81, pp. 2861-2874.

Normark, W. R. and Piper, D. J. W. (1969) Deep-sea fan-valleys, past and present: Geol. Soc. Amer. Bull., vol. 80, pp. 1859-1866.

Parea, G. C. (1968) The possibility of reconstruction of the pre-tectonic current trend in allochthonous turbidite formations, in Internat. Geol. Cong. Rep., 23rd Sess., Proc. Sec. 3 (Prague), pp. 225-234.

Parkash, B. (1970) Downslope changes in sedimentary structures in Ordovician turbidite greywackes: Jour. Sed. Petrol., vol. 40, pp. 572-590.

Phleger, F. B. (1951) Displaced Foraminifera Faunas, in Turbidity currents and the Transportation of coarse sediment to deep water: SEPM Spec. Pub. No. 2, pp. 66-75.

Piper, D. J. W. (1970a) A Silurian deep sea fan deposit in western Ireland and its bearing on the nature of turbidity currents: Jour. Geol., vol. 78, pp. 509-522.

----------(1970b) Transport and deposition of Holocene sediment on La Jolla deep sea fan, California: Marine Geol., vol. 8, pp. 211-227.

---------- and Marshall, N. F. (1969) Bioturbation of Holocene sediments on La Jolla Deep Sea Fan, California: Jour. Sed. Petrol., vol. 39, pp. 601-606.

Pratt, R. M. (1968) Atlantic continental shelf and slope of the United States -- physiography and sediments of the deep-sea basin: U. S. Geol. Surv. Prof. Pap. 529-B, 44 pp.

Radomski, A. (1961) On some sedimentological problems of the Swiss flysch series: Eclog Geol. Helv., vol. 54, pp. 451-459.

Reimnitz, E. and Gutierrez-Estrada, M. (1970) Rapid changes in the head of the Rio Balsas submarine canyon system, Mexico: Marine Geol., vol. 8, pp. 245-258.

Rich, J. L. (1950) Flow markings, groovings, and intra-stratal crumplings as criteria for recognition of slope deposits, with illustrations from Silurian rocks of Wales: Amer. Assoc. Petrol. Geol. Bull., vol. 34, pp. 717-741.

---------- (1951) Three critical environments of deposition and criteria for recognition of rocks deposited in each of them: Geol. Soc. Amer. Bull., vol. 62, pp. 1-20.

Rodolfo, K. S. (1969) Sediments of the Andaman Basin, northeastern Indian Ocean: Marine Geol., vol. 7, pp. 371-402.

Rona, P. A. (1969a) Linear "Lower Continental Rise Hills" off Cape Hatteras: Jour. Sed. Petrol., vol. 39, pp. 1132-1141.

---------(1969b) Middle Atlantic continental slope of United States, deposition and erosion: Amer. Assoc. Petrol. Geol. Bull., vol. 53, pp. 1453-1465.

--------(1970a) Comparison of continental margins of eastern North America at Cape Hatteras and northwestern Africa at Cap Blanc: Amer. Assoc. Petrol. Geol. Bull., vol. 54, pp. 129-157.

---------(1970b) Submarine canyon origin on upper continental slope off Cape Hatteras: Jour. Geol., vol. 78, pp. 141-152.

--------- and Clay, C. S. (1967) Stratigraphy and structure along a continuous seismic reflection profile from Cape Hatteras, North Carolina, to the Bermuda Rise: Jour. pp. 2107-2130.

Rowe, G. T. and Menzies, R. J. (1968) Deep bottom currents off the coast of North Carolina: Deep-Sea Res., vol. 15, pp. 711-719.

Rücklin, H. (1938) Stromungs-marken im Unteren Muschelkalk des Saarlandes: Senckenbergiana Lethaea, vol. 20, pp. 94-114.

Ryan, W. B. F. and Heezen, B. C. (1965) Dynamical processes of sedimentation on the Seine abyssal plain: Geol. Soc. Amer. Spec. Pap. 82, p. 171.

----------, _et al._ (1965) Sediments on the Tyrrhenian abyssal plain: Geol. Soc. Amer. Bull., vol. 76, pp. 1261-1282.

Sanders, J. E. (1963) Concepts of fluid mechanics provided by primary sedimentary structures: Jour. Sed. Petrol., vol. 33, p. **173-179.**

---------- (1965) Primary sedimentary structures formed by turbidity currents and related resedimentation mechanisms, in Primary sedimentary structures: S.E.P.M. Spec. Publ. 12, pp. 192-219.

Schneider, E. D., et al. (1967) Further evidence of contour currents in the Western North Atlantic: Earth and Planet. Sci. Letters, vol. 2, pp. 351-359.

Scholl, D. W. (1970) The structure and origin of the large submarine canyons of the Bering Sea: Marine Geol., vol. 8, pp. 187-210.

----------, et al. (1966) Exposure of basement rock on the continental slope of the Bering Sea: Science, vol. 153, no. 3739, pp. 992-994.

----------, et al. (1968) Geologic history of the continental margin of North America in the Bering Sea: Marine Geol., vol. 6, pp. 297-330.

Schwab, F. L. (1971) Harpers Formation, Central Virginia: A Sedimentary Model: Jour. Sed. Petrol., vol. 41, pp. 139-149.

Schwartzose, R. A. and Isaacs, J. D. (1969) Transient circulation event near the deep ocean floor: Science, vol. 165, no. 3896, pp. 889-891.

Sedimentation Seminar (Ind. Univ. & Univ. Cin.) (1969) Bethel Sandstone (Mississippian) of western Kentucky and south-central Indiana, a submarine-channel fill: Kentucky Geol. Surv., Rept. Invest. 11, 24pp.

Seilacher, A. (1962) Paleontological studies on turbidite sedimentation and erosion: Jour. Geol., vol. 70, pp. 227-234.

Shepard, F.P. (1951a) Mass movements in submarine canyon heads: Am. Geophys. Union Trans., vol. 32, pp. 405-418.

--------- (1951b) Transportation of sand into deep water, in Turbidity Currents and the Transportation of coarse sediment to deep water: S.E.P.M. Spec. Pub. No. 2, pp. 53-65.

---------- (1961) Deep-sea sands: 21st Internatl. Geol. Congr. Repts., pt. 23, pp. 26-42.

---------- and Buffington, E. C. (1968) La Jolla submarine fan-valley: Marine Geol., vol. 6, pp. 107-143.

---------- and Dill, R. F. (1966) Submarine canyons and other sea valleys: Rand McNally, Chicago, 381 pp.

---------- and Marshall, N. F. (1969) Currents in La Jolla and Scripps submarine canyons: Science, vol. 165, no. 3889, pp. 177-178.

----------, et al. (1969) Physiography and sedimentary processes of La Jolla submarine fan and fan-valley, California: Amer. Assoc. Petrol. Geol. Bull., vol. 53, pp. 390-420.

Snavely, P. D., Jr. et al. (1964) Rhythmic-bedded eugeosynclinal deposits of the Tyee Formation, Oregon Coast Range, in Symposium on cyclic sedimentation: Kansas Geol. Surv. Bull. 169, pp. 461-480.

Spencer, J. W. (1903) Submarine valleys off the American coast and in the North Atlantic: Bull. Geol. Soc. Amer., vol. 14, pp. 207-226.

Stanley, D. J. (1967) Comparing patterns of sedimentation in some ancient and modern submarine canyons: Earth Planet. Sci. Letters, vol. 3, pp. 371-380.

---------- (1968) Graded bedding - sole marking - graywacke assemblage and related sedimentary structures in some carboniferous flood deposits, eastern Massachusetts, in Late Paleozoic and Mesozoic Continental Sedimentation, Northeastern North America: Geol. Soc. Amer. Spec. Pap. 106, pp. 211-239.

---------- and Silverberg, N. (1969) Recent slumping on the continental slope off Sable Island Bank, southeast Canada: Earth and Planet. Sci. Letters, vol. 6, pp. 123-133.

Stetson, H. C. and Smith, J. F. (1937) Behavior of suspension currents and mud slides on the continental slope: Amer. Jour. Sci., vol. 35, pp. 1-13.

Stride, A. H., Curray, J. R., Moore, D. G., Belderson, R. H. (1969) Marine geology of the Atlantic Continental margin of Europe: Philosophical Trans. Royal Soc. London, Ser. A, vol. 264, pp. 31-75.

Strider, B. (1827a) Notice geognostique sur quelques parties de la chaine de Stockhorn et sur la houille du Siemmenthal, canton Berne: Am. Sci. Nat., XI, Paris, 1.

---------- (1827b) Geognostische Bermerkungen uber einige Teile der nordlichen Alpenkette: Z. Mineral., 1:39.

Sullwold, H. H., Jr. (1960) Tarzana Fan, deep submarine fan of Late Miocene age, Los Angeles County, California: Amer. Assoc. Petrol. Geol. Bull., vol. 44, pp. 433-457.

---------- (1961) Turbidites in oil exploration, in Geometry of sandstone bodies: Amer. Assoc. Petrol. Geol., Tulsa, pp. 63-81.

Sutton, R. G. (1965) Use of sedimentary parameters in the differentiation of North Atlantic Shelf, Slope and Abyssal Plain sands: Geol. Soc. Amer. Spec. Pap. 82, p. 202.

Swann, D. H., et al. (1965) The Borden Siltstone (Mississippian) delta in southwestern Illinois: Ill. State Geol. Surv. Circ. 386, 20 p.

Ten Haff, E. (1959) Properties and occurrences of turbidites: Geol. en Mijnbouw (NW Ser.), 21e Jaargang, pp. 217-222.

Thomson, A. F. and Thomasson, M. R. (1969) Shallow to deep water facies development in the Dimple limestone (Lower Pennsylvanian) Marathon Region, Texas: S.E.P.M. Spec. Pub. 14, pp. 57-78.

Uchupi, E. (1967) Slumping on the Continental Margin southeast of Long Island, N.Y.: Deep-sea Research, vol. 14, pp. 635-639.

---------- and Emery, K. O. (1967) Structure of continental margin off Atlantic Coast of United States: Amer. Assoc. Petrol. Geol. Bull., vol. 51, pp. 223-234.

---------- and ---------- (1968) Structure of the continental margin off Gulf Coast of the United States: Amer. Assoc. Petrol. Geol. Bull., vol. 52, pp. 1162-1193.

Van Andel, T. H. and Veevers, J. J. (1967) Morphology and sediments of the Timor Sea: Aust. Bur. Min. Res., Geol. and Geophys. Bull., vol. 83, 127 p.

Van Siclen, D. C. (1958) Depositional topography--examples and theory: Amer. Assoc. Petrol. Geol. Bull., vol. 42, pp. 1897-1913.

Vassolvic, N. B. (1957) Flysh i tectonicheskaia obstonovka ego otrazovaniia: Intern. Geol. Congr., 20th Mexico, 1956, Rept. 5, pp. 303-304, 327-343.

Veatch, A. D. and Smith, P. A. (1939) Atlantic submarine valleys of the United States and the Congo submarine valley: Geol. Soc. Amer. Spec. Pap. 7, 10 p.

Von Der Borch, C. C., et al. (1970) Sedimentation and structure of the continental margin in the vicinity of the Otway Basin, Southern Australia· Marine Geol., vol. 8 (1), pp. 59-83.

Walker, R. G. (1965) The origin and significance of the internal sedimentary structures of turbidites: Proc. Yorkshire Geol. Soc., vol. 35, pp. 1-32.

--------(1966a) Deep channels in turbidite-bearing formations: Amer. Assoc. Petrol. Geol. Bull., vol. 50, pp. 1899-1917.

--------(1966b) Shale grit and Grindslow shales: transition from turbidite to shallow water sediments in Upper Carboniferous of northern England: Jour. Sed. Petrol., vol. 36, pp. 90-114.

---------- (1967) Turbidite sedimentary structures and their relationship to proximal and distal depositional environments: Jour. Sed. Petrol., vol. 37, pp. 25-43.

---------- (1969) The juxtaposition of turbidite and shallow-water sediments, a study of a regressive sequence in the Pennsylvanian of North Devon, England: Jour. Geol., vol. 77, pp. 125-143.

---------- (1971) Nondeltaic Depositional Environments in the Catskill Clastic Wedge (Upper Devonian) of Central Pennsylvania: Bull., Geol. Soc. of Amer., vol. 82, pp. 1305-1326.

Walton, E. K. (1967) The sequence of internal structures in turbidites: Scottish Jour. Geol., vol. 3, pp. 306-317.

Slope and Abyssal Systems Addendum

Asquith, D.O.,(1970) Depositional topography and major marine environments, Late Cretaceous, Wyoming: Bull. Amer. Assoc. Petrol. Geol., vol. 54, pp. 1184-1224.

Bouma, A.H. (1965) Sedimentary characteristics of samples collected from some submarine canyons: Marine Geology, vol. 3, pp. 291-321.

Burke, K. (1966) The Yallahs Basin: a sedimentary basin southeast of Kingston, Jamaica: Marine Geology, vol. 5, pp. 45-60.

Delaney, F.M., (ed.) (1970) The geology of the East Atlantic continental margin. 1. General and economic papers: Rept. No. 70/13, Inst. geol. Sci. (Great Br.), 176 pp.

Delany, F.M., (ed.) (1971) ICSU/SCOR Working Party 31 Symposium, Cambridge: The geology of the East Atlantic continental margin. 2. Europe: Report 70/14. Inst. geol. Sci, (Great Br.) 170 pp.

Delany, F.M., (ed.) (1970), ICSU/SCOR Working Party 31 Symposium, Cambridge 1970. The geology of the East Atlantic continental margin. 2. Africa: Rep. No. 70/16, Inst. geol. Sci., 209 pp.

Ericson, D.B., Ewing M., Heezen, B.C., and Wollin G. (1955) Sediment deposition in deep Atlantic: Geol. Soc. Amer. Spec. Paper 62, pp. 205-220.

Felix, D.W. and Gorsline, D.S. (1971) Newport Submarine Canyon, California: an example of the effects of shifting loci of sand supply upon canyon position: Marine Geology, vol. 10, pp. 177-198.

Galloway, W.E. and Brown, L.F., Jr. (1972) Depositonal systems and shelf-slope relationships in Upper Pennsylvanian Rocks, North-central Texas: Univ. Texas, Bur. Econ. Geology Rept. Inv. 75, 63 pp.

Gorsline, D.S. (1963) Bottom sediments of the Atlantic shelf and slope off the southern United States: Jour. Geol., vol. 71, pp. 422-440.

Gorsline, D.S. and Emery, K.O. (1959) Turbidity current deposits in San Pedro and Santa Monica Basins off Southern California: G.S.A. Bull., vol. 70, pp. 279-290.

Heezen, B.C. (1968) The Atlantic continental margin, Univ. Missouri at Rolla Jour., no. 1, ser. 1, pp. 5-25.

Heezen, B.C., et al. (1966) Shaping of the continental rise by deep geostrophic contour currents: Science, vol. 152, no. 3721, pp. 502-508.

Hoyt, W.V. (1959) Erosional channel in the middle Wilcox near Yoakum, Lavaca County, Texas: Gulf Coast Assoc. Geol. Socs. Trans., vol. 9, pp. 41-50.

Hubert, J.F. (1966) Sedimentary history of Upper Ordovician geosynclinal rocks, Girvan, Scotland: J.S.P., vol. 36, pp. 677-699.

Jacka, A.D., et al. (1968) Permian Deep Sea Fans of the Delaware Mountain Group (Guadalupian) Delaware Basin: Guadalupian Facies, Apache Mountain area, West Texas Permian Basin Sec., Soc. Econ. Pal. Mineral. Pub. 68-11, pp. 49-90.

Kuenen, P. and Migliorini, C.I. (1950) Turbidity currents as a cause of graded bedding: J.G., vol. 58, pp. 91-127.

Lehner, P. (1969) Salt tectonics and Pleistocene stratigraphy on continental slope of northern Gulf of Mexico: Bull. Amer. Assoc. Petrol. Geol., vol. 53, pp. 2431-2479.

Lineback, J.A. (1969) Illinois Basin - sediment starved during Mississippian: Amer. Assoc. Petrol. Geol. Bull., vol. 53, pp. 112-126.

McBride, E.F., (1970) Flysch sedimentation in the Marathon Region, Texas: Geol. Assoc. Canada, Spec. Paper 7, pp. 67-83.

McMaster, R.L., DeBoer, J., and Ashraf, A. (1970) Magnetic and seismic reflection studies on continental shelf off Portuguese Guinea, Guinea, and Sierra Leone, West Africa: AAPG, Bull, vol. 54, pp. 158-167.

Marschalko, B.D. (1963) Sedimentary structures and paleocurrents in the marginal lithofacies of the Central-Carpathian flysch: Turbidites, Developments in Sedimentology 3, Elsevier, Amsterdam, pp. 106-126.

Menard, H. W. (1960) Possible pre-Pleistocene deep-sea fans off central California: Geol. Soc. Amer. Bull., vol. 71, pp. 1271-1278.

Middleton, G.V. (1969) Turbidity currents in: The new concepts of continental margin sedimentation- AGI Short Course Lecture Notes: GM-A-1 to GM-A-20.

Middleton, G.V. (1969) Grain flows and other mass movements down slopes in: The new concepts in continental margin sedimentation - AGI Short Course Lecture Notes: GM-B-1 to GM-B-14.

Moore, G.T. and Asquith, D.O. (1971) Delta: term and concept: Bull. Geol. Soc. Amer., vol. 82, pp. 2563-2568.

Paine, W. R., (1968) Stratigraphy and sedimentation of subsurface Hackberry wedge and associated beds of southwestern Louisiana: Bull. Amer. Assoc. Petrol. Geol., vol. 52, pp. 322-342.

Piper, J.W. and Normark, J.W., (1971) Re-examination of a Miocene deep sea fan and fan valley, Southern California, Geol. Soc. Amer. Bull., vol. 82, pp. 1823-1830.

Shepard, F.P. (1965) Importance of submarine valleys in funneling sediments to the deep sea: Progress in Oceanography, vol. 3, pp. 321-332.

Shepard, Francis P., and Einsele, G., (1962) Sedimentation in San Diego trough and contributing submarine canyons: Sedimentology, vol. 1, pp. 81-133.

Stanley, D.J., (1969) Sedimentation in slope and base-of-slope environments in: The new concepts of continental margin sedimentation- AGI Short Course Lecture Notes, DJS-8-1 to DJS-8-25.

Stanley, D.J., (1969) Submarine channel deposits and their fossil analogs (''fluxoturbidites'') in: The new concepts of continental margin sedimentation- AGI Short Course Lecture Notes, DJS-9-1 to DJS-9-17.

Stanley, D.J., (1969) Turbidites, non-turbidites and outer continental margin paleogeography in: The new concepts of continental margin sedimentation- AGI Short Course Lecture Notes, DJS-13-1 to DJS-13-13.

Stanley, D.J. and Bouma, A.H., (1964) Methodology and paleogeographic interpretation of flysch formations: a summary of studies in the Maritime Alps: Turbidites, (Bouma and Brouwer, eds.,) Developments in Sedimentology 3, Elsevier, pp. 34-64.

Ten, Haaf E., (1964) Flysch formations of the northern Appennines in: Turbidites, Developments in Sedimentology 3, Elsevier, pp. 127-136.

Van Andel, Tj. H. and Komar, P.D., (1969) Ponded sediments of the Mid-Atlantic Ridge between 22 degrees and 23 degrees North latitude: Geol. Soc. Amer. Bull., vol. 80, pp. 1163-1190.

Van de Graaff, W.J.E. (1971) Three Upper Carboniferous, limestone rich, high destructive, delta systems with submarine fan deposits, Cantalbrian Mountains, Spain; Leidse Geologische Mededelingen, Deel 46, pp. 157-235.

Walker, R.G. (1970) Review of the geometry and facies organization of turbidites and turbidite-bearing basins: Geol. Assoc. Canada, Spec. Paper. 7, pp. 219-251.

EOLIAN SYSTEMS -- Summary

1. By definition, eolian systems are single-element systems being restricted to those developed through wind action; wind is an effective segregating agent, so that in addition eolian systems consist chiefly of sand only; sand characterized by uniformity in composition and paucity of structural types; contrasts with compound-element systems like deltas

2. Intrafacies relationships do not occur; petrology is fairly uniform; main consideration must be on structures and stratification units; very little study made of internal structures of modern dunes

3. Recognition of large eolian units is relatively easy; where dunes and eolian sands make up a minor part of a system, such as in fluvial or barrier-bar systems, preservation is rarer and recognition more difficult

4. Volumetrically important in fill of some sedimentary basins (especially Upper Paleozoic and Mesozoic of Colorado Plateau, U. S. A.); modern dune fields occupy 20% of land surface

5. Principal characteristics are large-scale cross beds, few fossils except in fine-grained wind deposits (loess), frosted grains common in modern dune sands. Petrology: grain/matrix ratio is high because much clay has been winnowed out; depending on source, framework fraction may be immature; sorting generally fair to good; micaceous minerals generally absent; rounding is good; cementing agents generally chemical; conglomerates are rare.

6. Sedimentary structures: Prime structure is cross bedding, which may be very large scaled; individual sets as much as 100 feet; inclination is generally unimodal, excepting in dunes formed under seasonally changing wind directions (sief dunes and some coastal dunes)

7. Dune types

   a. Transverse dune: nearly straight sand ridge oriented at approximately right angles to the dominant, effective wind direction
   b. Barchan dune: crescent form; horns of crescent extend downwind; closely related to transverse dune and apparently formed by a unidirectional wind; in many areas, barchans are scattered from one another on flat surfaces; in other areas tend to coalesce, form complex masses, and show gradation to transverse dunes
   c. Parabolic dune: U- or V-shaped dune representing a type of blowout in that the central part has moved forward with respect to the arms; arms commonly anchored by vegetation and entire dune is relatively stable; commonly forms the downwind margin of a dune field

d. Dome dune: low circular dune that forms a mound on the upwind margin of a dune field; seems to develop where dune height is inhibited by an unobstructed strong wind

e. Seif (longitudinal) dune: long, nearly straight sand ridge commonly parallel to other similar ridges and separated from them by wide, flat interdune surfaces; dune normally is oriented along a line that is the vector of two converging wind directions; common in parts of North Africa and Australia

f. Reversing dune: dune that tends to develop unusual height but that migrates only a limited distance to seasonal shifts in dominant wind direction resulting in alternate movements in nearly opposite directions; shape may resemble a barchan or transverse dune but differs in complexity of internal structures

g. Star dune: type of sand body developed locally in Saudi Arabia and parts of North Africa; has a central point from which 3 or more arms or ridges radiate in various directions

8. Trend in dune forms: Generally develop as follows, progressively away from source and in downwind direction: dome, transverse, barchan, and parabolic

9. Rate of dune migration: Highest upwind and lowest among the parabolic dunes downwind; dissipation of energy across the dune field

10. Characteristics and internal structures:

a. Transverse dunes: among high dunes; form long, nearly parallel ridges at right angles to dominant wind direction; sorting fair to good but not as good as in barchans and parabolic dunes farther downwind; in cross section (across dune parallel to wind direction), steeply dipping laminae form the lower 2/3 of dune; dips 30° to 34°; foresets large scale, some extending as much as 60 feet; bounding surfaces of sets have moderately high dips, mostly from 20° to 25°; deposits in upper third of dune consist of relatively thin, gently dipping to horizontal sets, 2-3 feet thick; laminae within these sets dip moderately (10° to 15°); thinning and flattening of cross strata in upper part result from periodic truncation as upward growth becomes more difficult; some wavy laminae in steep foresets due to slumping

b. Barchan dunes: lee side is steep slipface with plan outline concave downwind; windward side much more gentle slope, convex in outline in upwind direction; early stage of sand accumulation represents deposits on windward side and consists of relatively thin sets of cross strata whose laminae dip at 25° to 35°; these bounded by surface of low downwind dip, commonly 2° to 5°; on lee side of dune most surfaces of bounding sets dip from 20° to 30°; individual laminae extend 40 feet or more; structures in barchan wing or horn consist of nearly flat-lying surfaces bounding cross strata sets, most of which range from 2 to 5 feet and are tapered toward dune margin

c. Parabolic dunes: conspicuous along the downwind margins of dune fields; develop in "U" and "V" shapes; arms partially anchored by vegetation; sands well sorted; structural pattern formed of high-angle cross strata that extend across much of the lower part of dune; laminae dip 20° to 35°, and bounding surfaces dip 10° to 20°; feature not found in other dunes is downward curvature of the high-angle foresets near the dune front; probably the result of dune shape; the protruding frontal margins of the dune expose the slipfaces and permit cross winds to erode it and oversteepen the lower part

d. Dome dunes: occur immediately downwind from source, low isolated mounds, round or oval in plan with rounded tops; differ notably from other types of dunes in size and shape and also in absence of steep avalanche faces; medium grained sand as in other dunes but with much poorer sorting with higher percentages of fine and coarse sediments (probably proximity of source); dips of cross beds essentially those of a dune that starts as a transverse dune and is later modified by strong winds that preclude high growth; much sand is moved to lee side in suspension; thus sand accumulates in moderate-to long-angle laminae on lee side

11. Trends in dune fields: (Downwind) inclination of cross beds increases and finally decreases; dune height begins low, increases, and then becomes moderate; dune crests begin in circular pattern, become straight, then develop downwind arms and finally upwind arms; grain size decreases; sorting increases, vegetation stabilization increases; directional variance increases

12. Multiple parallel truncation bedding planes or "water table bedding": Many ancient eolian deposits show extensive smooth parallel surfaces that sharply truncate cross bedding and are not depositional; these are commonly iron-cemented; since wind has little effect upon water-saturated materials, assumption is that conditions developed where dune fields were deflated to water table, creating smooth, flat surfaces that later separate intervals of cross bedded sands; necessary conditions are abundant sand, strong wind action, and a water table that rises with sedimentation and at some time reaches the surface

13. Mineral reservoirs: Although permeabilities and other host conditions are ideal for accumulation of oil and gas, eolian sands are singularly nonproductive; a principal limitation is lack of source beds. Eolian sands apparently provide reservoirs only where extensive upward migration of oil and gas has

occurred. Source for oil and gas produced in the North Sea from presumed eolian sands is considered to be at depth.

EOLIAN SYSTEMS

Selected References

Allen, J. R. L. (1965) The sedimentation and paleogeography of the Old Red Sandstone of Anglesey, North Wales: Proc. Yorkshire Geol. Soc., vol. 35, pp. 139-187.

Bagnold, R. A. (1941) The physics of blown sand and desert dunes: Methuen, London, 265 pp.

Baker, T. A. (1953) Sand dunes on northern Padre Island: Unpbl. Masters Thesis, Univ. of Kansas.

Belly, P. Y. (1962) Sand movement by wind: Inst. Eng. Res., Hydr. Eng. Wave Res. Projects, Univ. of Calif., Berkeley, LXXII.

------- (1964) Sand movement by wind: U. S. Army Coastal Engineering Research Center, Tech. Memo no. 1, pp. 1-38.

Bigarella, J. J. and Salamuni, R. (1961) Early Mesozoic wind patterns as suggested by dune bedding in the Botucatu Sandstone of Brazil and Uruguay: Bull. Geol. Soc. Amer., vol. 72, pp. 1089-1106.

------- et al. (1969) Coastal dune structures from Parana (Brazil): Marine Geology, vol. 7, pp. 5-55.

Biswas, S. K. (1971) The Milolite rocks of Kutch and Kathianar (western India): Sed. Geology, vol. 5, pp. 147-167.

Chepil, W. S. and Milne, R. A. (1939) Comparative study of soil drifting in the field and in a wind tunnel: Sci. Agr., vol. 19, pp. 249-257.

------- (1945) Dynamics of wind erosion, 1. The nature of movement of soil by wind: Soil Science, vol. 60, pp. 305-320.

Cooper, W. S. (1958) Coastal sand dunes of Oregon and Washington: America Mem. 72, 169 pp.

Crissey, G. B. (1928) Pre-Indiana sand dunes and shoreline of the Lake Michigan Basin: Univ. Chicago Press, Chicago, 80 pp.

Dickinson, W. R. (1968) Singatoka dune sands, Viti Levu (Fiji): Sed. Geology, vol. 2, pp. 115-124.

Evans, J. R. (1962) Falling and climbing sand dunes in the Cronese ("Cat") Mountain area, San Bernardino County, California (note): Jour. Geol., vol. 20, pp. 107-113.

Folk, R. L. (1966) Sands of the Simpson Desert, Maryvale Station, No. Territory, Austr.: A Contribution to the Problem of Paleozoic Bimodal-Supermature Quartz-Arenites: Geol. Soc. Amer. Spec. Paper 101, p. 69.

------- (1968) Bimodal supermature sandstones: product of the desert floor: Proc. Int. Geol. Cong., Section 8, pp. 9-33.

Friedman, G. M. (1961) Distinction between dune, beach and river sands from their textural characteristics: Jour. Sed. Petrology, vol. 31, pp. 514-529.

Game, P. M. (1964) Observations on a dustfall in the eastern Atlantic, February, 1962: Jour. Sed. Petrology, vol. 34, no. 2, p. 355.

Giles, R. T. and Pilkey, O. H. (1965) Atlantic beach and dune sediments of the southern United States: Jour. Sed. Petrology, vol. 35, pp. 900-910.

Harris, S. A. (1957) Mechanical constitution of certain present-day Egyptian dune sands: Jour. Sed. Petrology, vol. 27, no. 3, pp. 421-434.

Hayes, M. O. (1965) Sedimentation on a semiarid wave dominated coast (South Texas) with emphasis on hurricane effects: Univ. Texas, Dept. of Geol. Sciences Ph.D. Dissertation, 385pp.

Horikawa, K. and Shen, W. H. (1960) Sand movement by wind (on the characteristics of sand traps): U. S. Beach Erosion Board, Tech. Mem., vol. 119, 51 pp.

Hoyt, J. H. (1966) Air and sand movements to the lee of dunes: Sedimentology, vol. 7, no. 2, pp. 137-143.

Huffman, G. G. and Price, W. A. (1949) Clay dune formation near Corpus Christi, Texas: Jour. Sed. Petrology, vol. 19, no. 3, pp. 118-127.

Inman, D. L. (1966) Coastal sand dunes of Gerrero Negro, Baja California, Mexico: Bull. Geol. Soc. Amer., vol. 77, pp. 787-802.

Johnson, R. B. (1968) The Great Sand Dunes of southern Colorado: The Mountain Geologist, vol. 5, no. 1, pp. 23-29.

Jordan, W. M. (1965) Prevalence of sand dune types in the Sahara Desert: Geol. Soc. Amer. Spec. Paper 82, pp. 104-105.

Kiersch, G. A. (1950) Small-scale structures and other features of Navajo Sandstone, northern part on San Rafael swell, Utah: Bull. Amer. Assoc. Petrol. Geol., vol. 34, pp. 923-942.

Kuenen, Ph. H. (1960) Experimental abrasion 4: Eolian action: Jour. Geology, vol. 68, pp. 427-449.

Kurz, H. (1942) Florida dunes and scrub, vegetation and geology: State of Fla. Dept. of Conservation, Fla. Geol. Survey, 154 pp.

Land, L. S. (1964) Eolian cross-bedding in the beach dune environment, Sapelo Island, Georgia: Jour. Sed. Petrology, vol. 34, no. 2, p. 389.

Long, J. T. and Sharp, R. P. (1964) Barchan dune movement in Imperial Valley, California: Bull. Geol. Soc. Amer., vol. 75, pp. 149-156.

Lugn, A. L. (1960) The origin and sources of loess in the Great Plains in North America: Int. Geol. Congress, Rept. 21, Part 21, pp. 223-235.

MacCarthy, G. R. and Huddle, J. W. (1938) Shape sorting of sand grains by wind action: Amer. Jour. Sci., vol. 35, pp. 64-73.

Madigan, C. T. (1936) The Australian sand ridge desert: Geog. Review, vol. 26, pp. 205-227.

Mattox, R. B. (1955) Eolian shape sorting: Jour. Sed. Petrology, vol. 25, pp. 111-114.

McBride, E. F. and Hayes, M. O. (1963) Dune cross-bedding on Mustang Island, Texas: Bull. Amer. Assoc. Petrol. Geol., vol. 46, pp. 546-551.

McKee, E. D. (1934) The Coconino Sandstone--its history and origin: Carnegie Inst. Washington Publ. 440, Contr. Paleontology, pp. 77-115.

------- (1966) Structures of dunes at White Sands National Monument, New Mexico (and comparison with structure of dunes from other selected areas): Sedimentology, vol. 7, pp. 3-69.

------- and Tibbetts, G. C., Jr. (1964) Primary structures of a sief dune and associated deposits in Libya: Jour. Sed. Petrology, vol. 34, pp. 5-17.

Merriam, R. (1969) Source of sand dunes of southeastern California and northwestern Sonora, Mexico: Bull. Geol. Soc. Amer., vol. 80, pp. 531-534.

Norris, R. M. (1966) Barchan dunes of Imperial Valley, California: Jour. Geology, vol. 74, pp. 292-306.

------- and Norris, K. S. (1961) Algodones dunes of southeastern California: Bull. Geol. Soc. Amer., vol. 72, pp. 605-620.

O'Brien, M. P. and Rindlaub, B. D. (1936) The transportation of sand by wind: Civil Eng. (N. Y.), vol. 6, pp. 325-327.

Peacock, J. D. (1966) Contorted beds in the Permo-Triassic aeolian sandstones of Morayshire: Bull. Geol. Survey Great Britain, vol. 24, pp. 157-162.

Pewe, T. L. (1968) Loess deposits of Alaska: Proc. Int. Geol. Cong., Section 8, pp. 297-311.

Poole, F. G. (1964) Paleowinds in the western United States: in Problems in paleoclimatology, N.A.T.O. Paleoclimates Conf. Proc. Univ. Newcastle upon Tyne, 1963, London, Interscience Publ., pp. 394-405.

Price, W. A. and Kornicker, L. S. (1961) Marine and lagoonal deposits in clay dunes, Gulf Coast, Texas: Jour. Sed. Petrology, vol. 31, pp. 245-255.

Pryor, W. A. and Amaral, E. J. (1971) Large-scale cross-stratification in the St. Peter Sandstone, Bull. Geol. Soc. Amer., vol. 82, pp. 239-244.

Rempel, P. (1936) The crescentic dunes of the Salton Sea and their relation to the vegetation: Ecology, vol. 17, pp. 347-358.

Sharp, R. P. (1966) Kelso dunes, Mojave Desert, California: Bull. Geol. Soc. Amer., vol. 77, pp. 1047-1074.

Shepard, F. P. and Young, R. (1961) Distinguishing between beach and dune sands: Jour. Sed. Petrology, vol. 31, pp. 196-214.

Shotten, F. W. (1956) Some aspects of the New Red desert in Britain: Liverpool and Manchester Geol. Jour., vol. 1, pp. 450-465.

Smalley, I. J. and Vita-Fizi, C. (1968) The formation of fine particles in sandy deserts and the nature of "desert" loess: Jour. Sed. Petrology, vol. 38, pp. 766-775.

Smith, H. T. U. (1966) Wind-formed pebble ripples in Antarctica (abs.): Geol. Soc. Amer. Spec. Paper 87, p. 160.

Stokes, W. L. (1961) Fluvial and eolian sandstone bodies in Colorado Plateau, in Geometry of sandstone bodies: Amer. Assoc. Petrol. Geol., Tulsa, pp. 151-178.

------- (1964) Eolian varving in the Colorado Plateau: Jour. Sed. Petrology, vol. 34, pp. 429-431.

------- (1968) Multiple parallel-truncation bedding planes--a feature of wind-deposited sandstone formations: Jour. Sed. Petrology, vol. 38, pp. 510-515.

Tanner, W. F. (1964) Eolian ripple marks in sandstone: Jour. Sed. Petrology, vol. 34, p. 432.

Thompson, D. B. (1969) Dome-shaped aeolian dunes in the Frodsham member of the so-called "Keuper" sandstone formation at Frodsham, England: Sed. Geology, vol. 3, pp. 263-289.

Thompson, D. G. (1929) The Mojave Desert Region: U. S. Geol. Survey Water Supply Paper 578.

Thompson, W. O. (1937) Original structures in beaches, bars, and dunes: Bull. Geol. Soc. Amer., vol. 48, pp. 723-751.

Tolman, C. F. (1909) Erosion and deposition in the southern Arizona bolson region: Jour. Geology, vol. 17, pp. 136-163.

Udden, J. A. (1898) The mechanical composition of wind deposits: Augustana Library Pub. no. 1, 69 pp.

Zingg, A. W., 1953, Wind-tunnel studies of the movement of Sedimentary material, Iowa Univ., Studies Eng. Bull., vol. 34, pp. 111-135.

LACUSTRINE SYSTEMS -- Summary

1. Important associations: Origins of oil shales, turbidity and density current processes, delineation of Gilbert-type deltas

2. Definition: Reasonably unique systems, develop in terrestrial closed depressions, under conditions of some restriction, low energy, without influence of tides and other modifying features of ocean-water masses; sensitive to climate and variation in climate; principal occurrence in intermontaine basins with tectonic association and in large constructional systems such as deltas; minor parts of other depositional systems; water-body properties function of temperature and chemistry, result in distinct lacustrine facies

3. Types:

   Open or drainage lakes: water input and output occurs by streams, by seepage, or by both
   Closed lakes: input and output occurs only by surface rainfall and evaporation; common to arid regions
   Types commonly associated temporally

4. Limnological principles:

   In temperate regions, warming and cooling of lake water body results in zonation, upper level epilimnion and lower level hypolimnion separated by thermocline; upper level circulates, well oxygenated; lower level more or less stagnant; when temperatures or densities of two water masses are similar, as in spring and fall, overturn occurs and entire water mass is circulated
   In tropical and subtropical lakes only one overturn per year
   In addition to above thermal stratification, water mass may be stratified chemically, giving an upper oxygenated epilimnion and lower stagnant saline hypolimnion

5. Varving: Principal means of recognizing nonglacial varves is organic-layer criterion; organic layer represents seasonal plankton growth and organic precipitation; blooming may not always be seasonal, may skip a season, may be more than 1 bloom per season; bloom represents organic layer, nonorganic components inserted

6. Lake models:

   Stratified lake model: including both thermal and chemical stratification or combinations; characterized by lower dense water hypolimnion, which gives a distinct lake facies with varving, good preservation of biota, reducing conditions, oil shales; unique to lakes and where developed easily recognized; not much inflow and terrigenous contribution but will develop distinct shoreline features, shoreface, and beach in terrigenous bounding terrains, oolite bars and algal mounds in carbonate bounding terrain

Open lake model: may develop stratification of water bodies but does not leave strong impress on facies; terrigenous input may be significant with development of marginal Gilbert deltas and underflow density or turbidity current deposits; commonly not recognized due to absence of unique hypolimnion or closed lake facies

7. Lake facies:

Closed or stratified lake facies: development of dense stagnant hypolimnion zone, either through temperature or chemical contrasts; very low physical energy; main characteristics include

1. Developed below effective wave base, few sedimentary structures indicative of water movement
2. Sediment chiefly silt and clay, with collochemical sediments dominant; nonclay materials chiefly subgraywackes and arkoses
3. Lack of bentonic organisms; no evidence of burrowers
4. Structures mainly due to syneresis; brecciation if evaporites formed; variety of hydroplastic structures from colloidal oozes
5. Abundant organic deposits; bituminous organic materials from aquatic organisms that settle through water column and form bottom oozes; chiefly planktonic algae, pollen, spores, and bacteria
6. Diagnostic, widely persistent, uniform laminae, characterized by some kind of very fine lamination, commonly varving
7. Originally high positive redox potentials with abundant pyrite and marcasite
8. Common minerals are zeolites, chiefly analcime
9. Exceedingly fine grained dolomite and salt casts; calcite precipitation gives argillaceous limestones or marls
10. Bedded salts, very commonly unusual types; calcium sulfate fairly common, but ordinary halite not common
11. Delicate preservation of organisms
12. Graded bedding common

Open lake facies: develops in absence of permanent hypolimnion, may be marginal to closed lake facies; displays no single criterion as diagnostic as varving; recognized on combination of features, including

1. Abundant mud cracks, subaerial desiccation structures
2. Oscillation ripple marks; current ripple marks locally but not common

3. Cement and associated accessory minerals commonly calcite; dolomite not common, salt casts may occur
4. Bioturbation extensive, with swimmers and trackers common
5. Parallel laminations with swash and rill structures common in beach zone
6. Oolites common in calcareous lakes; algal banks
7. Individual sedimentation units irregular and nonpersistent
8. Organic materials may not be common
9. Conditions of oxidation common, especially in marginal and terminal parts
10. Gilbert deltas and turbidity or density underflows common features

8. Gilbert deltas: Require similar density of river water and reservoir water body (homopyncnal inflow); commonly satisfied in lakes; three-dimensional mixing, rapid decrease in velocity, deposition within 4D of orifice, deposition of foresets at essentially angle of repose, marked by abundant climbing ripples; scale of foresets up to 50 feet depends on depth of water at stream mouth; foresets bounded by subaerial, flat-lying sediments above (topsets) and flat-lying sediments below (bottomsets); bottomsets may cover most of lake bottom if density underflows develop; Gilbert deltas represent coarse grained sediments, gradational to alluvial fans if gradient sufficiently steep; fans common marginal feature of lakes

9. Lacustrine underflows: Common features of nonstratified or poorly stratified lakes; obtained when density of discharging stream exceeds lake water; due to lower temperature, higher salinity, high sediment load; river water sinks below lake surface and travels along bottom; result in turbidites with graded bedding; especially well developed in such modern lakes as Lake Geneva, Lake Constance, Lake Mead

10. Ancient lacustrine systems: Well-studied ancient examples include the Green River (Eocene) of western U.S. (Bradley); Triassic Lockotong of northeastern U. S. and Maritime Canada (Van Houten); Lake Bonneville of western U. S. Great Basin (Gilbert); Lake Albert (Mississippian) of New Brunswick (Grinier)

11. Mineral reservoirs: Oil shales are common to many ancient lacustrine sequences (Green River, Albert, Scottish Carboniferous); generally magnesium marls rich in organic matter rather than shale; associated with closed lake facies or below-wave-base facies; reducing conditions; commonly varved; well preserved fossils; soft sediment deformation; organic closed lake facies are obvious source beds; very fine grained, collochemical size sediments precluded migration of sediment hydrocarbons, so source beds and reservoirs are the same units; also, lake facies are source of a variety of raw minerals and mineral salts

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Selected References

Allen, P. (1959) The Wealden environment: Anglo-Paris Basin: Roy. Soc. London, Ser. B, vol. 242, pp. 89-191.

Anderson, R. Y. and Kirkland, D. W. (1960) Origin, varves and cycles of Jurassic Todilo Formation, New Mexico: Amer. Assoc. Petrol. Geol. Bull., vol. 44, pp. 37-52.

------- (1969) Paleoecology of an Early Pleistocene Lake on the High Plains of Texas: Geol. Soc. Amer. Mem. 113, pp. 1-215.

Arnal, R. E. (1961) Limnology, sedimentation and micro-organisms of the Salton Sea, California: Geol. Soc. Amer. Bull., vol. 72, pp. 427-478.

Baer, M. L. (1969) Paleoecology of cyclic sediments of the lower Green River formation, central Utah: Brigham Young Geol. Studies, vol. 16, pp. 3-96.

Bates, C. C. (1953) Rational theory of delta formation: Amer. Assoc. Petrol. Geol. Bull., vol. 37, pp. 2119-2162.

Beals, H. L. (1966) Manganese-iron concentrations in Nova Scotia Lakes: Maritime Sediments, vol. 2, pp. 70-72.

Beerbower, J. R. (1961) Origin of cyclothems of the Dunkard Group (Upper Pennsylvanian - Lower Permian) in Pennsylvania, West Virginia, and Ohio: Geol. Soc. Amer. Bull., vol. 72, pp. 1029-1050.

Bonython, C. W. and Mason, B. (1953) The filling and drying of Lake Eyre: Geograph. Jour., vol. 119, pp. 321-330.

Bradley, W. H. (1929) The varves and climate of the Green River Epoch: U. S. Geol. Surv. Prof. Pap. 158-E, pp. 87-110.

------- (1929) Algae reefs and oolites of the Green River formation: U. S. Geol. Surv. Prof. Pap. 154-G, pp. 203-223.

------- (1931) Origin and microfossils of the oil shale of the Green River formation of Colorado and Utah: U. S. Geol. Surv. Prof. Pap. 168.

------- (1948) Limnology and the Eocene lakes of the Rocky Mountain Region, Geol. Soc. Amer. Bull.; vol. 59, pp. 635-648.

------- (1963) Paleolimnology, in Limnology in North America: Univ. Wisconsin Press, Madison, pp. 621-652.

------- (1964) Geology of the Green River formation: U. S. Geol. Surv. Prof. Pap. 496-A, 86 p.

------- (1970) Green River Oil Shale - Concept of origin extended: Geol. Soc. Amer. Bull.; vol. 81, pp. 985-1000.

Brown, J. S. (1923) The Salton Sea Region, California; a geographic, geologic and hydrologic reconnaissance: U. S. Geol. Surv. Water Supply Paper 497, 292 p.

Caspers, H. (1957) Black Sea and the Sea of Azov: Geol. Soc. Amer. Mem. 67 (1), pp. 803-889.

Coakley, J. P. and Rust, B. R. (1968) Sedimentation in an Arctic Lake: Jour. Sed. Petrol., vol. 38, pp. 1290-1300.

Crampton, C. B., et al. (1914) The geology of Caithness: Geol. Surv. Scotland, Mem., 194 p.

Dane, C. H. (1954) Stratigraphic and facies relationships of upper part of Green River Formation and lower part of Uinta Formation in Duchesne, Uinta and Wasatch Counties, Utah: Amer. Assoc. Petrol. Geol. Bull., vol. 28, pp. 405-425.

Dineley, D. L. and Williams, B. P. J. (1968) Sedimentation and paleoecology of the Devonian Escuminac Formation and related strata, Escuminac Bay, Quebec: Geol. Soc. Amer. Spec. Pap. 106, pp. 241-264.

Duff, P. McL. D., et al. (1967) Cyclic sedimentation, Chapter 3, Cycles in lacustrine regimes: Developments in Sedimentology 10, Elsevier, 280 p.

Eardley, A. J. (1938) Sediments of Great Salt Lake, Utah: Amer. Assoc. Petrol. Geol. Bull., vol. 22, pp. 1305-1411.

------- (1957) Hydrology of Lake Bonneville and sediments and soils of its basin: Geol. Soc. Amer. Bull., vol. 68, pp. 1141-1201.

Elliott, R. E. (1961) The stratigraphy of the Keuper series in southern Nottinghamshire: Yorkshire Geol. Soc. Proc., vol. 33, pp. 197-234.

El-Wakell and Wahby, S. S. (1970) Bottom sediments of Lake Manzalah, Egypt: Jour. Sed. Petrol., vol. 40, pp. 480-496.

Eugster, H. P. (1967) Hydrous sodium silicates from Lake Magadi, Kenya: Precursors of bedded chert: Science, vol. 157, no. 3793, pp. 1177-1180.

------- and Bradley, W. H. (1969) Geochemistry and paleolimnology of trona deposits and associated authigenic minerals of the Green River formation of Wyoming: U. S. Geol. Surv. Prof. Pap. 496-B, 68 p.

Farrand, W. R. (1969) The Quaternary history of Lake Superior: Proc. 12th Conf. Great Lakes Res., pp. 181-197.

Feth, J. H. (1955) Sedimentary features in the Lake Bonneville group in the east shore area, near Ogden, Utah: Utah Geol. Soc. Guidebook 10, pp. 45-69.

------- (1964) Review and annotated bibliography of ancient lake deposits (Precambrian to Pleistocene in the Western States): U. S. Geol. Surv. Bull., 1080, pp. 1-119.

Flint, R. F. and Gale, W. A. (1958) Stratigraphy and radiocarbon dates at Searles Lake, California: Amer. Jour. Sci., vol. 256, pp. 689-714.

Frey, D. G., editor (1963) Limnology in North America: The Univ. Wisc. Press, 734 p.

Frink, J. W. and Kues, A. (1954) Corcoran clay--a Pleistocene lacustrine deposit in San Joaquin Valley, California: Amer. Assoc. Petrol. Geol. Bull., vol. 38, pp. 2357-2371.

Gilbert, G. K. (1885) The topographic features of lake shores: U. S. Geol. Surv. Ann. Rept. 5, pp. 104-108.

------- (1890) Lake Bonneville: U. S. Geol. Surv. Mon. 1, 438 p.

Gillette, E. D. (1961) Oneida Lake pancakes: N. Y. Concerv., vol. 18, p. 41.

Gorham, E. and Swaine, D. (1965) The influence of oxidizing and reducing conditions upon the distribution of some elements in lake sediments: Limnol. Oceanogr., vol. 10, pp. 268-279.

Gould, H. R. (1954) Sedimentology (Chapter 8 in United States Department of the Interior Lake Mead Comprehensive Survey of 1948-1949): U. S. Geol. Surv. Lake Mead Comp. Surv. of 1948-49, Vol. VIII, pp. 211-323.

------- (1960) Turbidity currents, in Smith, et al., Comprehensive study of sedimentation in Lake Mead 1948-1949, U. S. Geol. Surv. Prof. Pap. 295, pp. 201-207.

Griner, H. R. (1962) Facies and sedimentary environments of Albert Shale, New Brunswick: Amer. Assoc. Petrol. Geol. Bull., vol. 46, pp. 219-234.

High, L. R., Jr. and Picard, M. D. (1965) Sedimentary petrology and origin of analcime-rick Popo Agie member, Chugwater (Triassic) formation, west-central Wyoming: Jour. Sed. Petrol., vol. 35, pp. 49-70.

Houbolt, J. J. H. C. and Jonker, J. B. M. (1968) Recent sediments in the eastern part of the lake of Geneva (Lac Leman): Geol. en Mijn., vol. 47, pp. 131-148.

Hough, J. L. (1958) Fresh-water environment of deposition of Precambrian iron formations: Jour. Sed. Petrol., vol. 28, pp. 414-430.

------- (1958) Geology of the Great Lakes: Univ. Ill. Press, Urbana, 313 p.

Hutchinson, G. E. (1957) Geography, physics, and chemistry: vol. 1 of a Treatise on Limnology, John Wiley and Sons, New York, 1065 p.

International Association for Great Lakes Research (1968) Proc., 11th Conf. on Great Lakes Res. held at the Univ. of Wisc.-Milwaukee, April 18-20, 699 p.

Johnson, D. G. (1969) Ferromanganese concretions in Lake Champlain: M.S. Thesis, Vermont Univ., 96 pp.

Jones, D. J. (1965) The Gilbert Type Delta (abst.): Amer. Assoc. Petrol. Geol. Bull., vol. 49, p. 345.

Kindle, E. M. (1932) Lacustrine concretions of manganese: Amer. Jour. Sci., vol. 24, pp. 496-504.

------- (1936) The occurrence of lake bottom manganiferous deposition in Canadian Lakes: Econ. Geol., vol. 31, pp. 755-760.

Kleerekoper, H. (1957) Une etude limnologique de la cheime des sediments de fond des lacs de l'Ontario Meridional Canada: Uitgevery Excelsion, 's-Gravenhage, 205 p.

Klein, G. deV. (1959) Sedimentary structures in the Beomidom formation, a Triassic lake deposit, Nova Scotia: Geol. Soc. Amer. Bull., vol. 70. p. 1630.

------- (1962) Sedimentary structures in the Keuper Marl (Upper Triassic): Geol. Mag., vol. 99, pp. 137-144.

------- (1962) Triassic sedimentation, Maritime Provinces, Canada: Geol. Soc. Amer. Bull., vol. 73, pp. 1127-1146.

Koesoemadinata, R. P. (1970) Stratigraphy and petroleum occurrence, Green River Formation, Redwash field, Utah: Part A: Quart. Colo. Sch. Mines, vol. 65, 77 p.

Kolb, C. R. and Von Lopik, J. R. (1966) Depositional environments of the Mississippi River Deltaic Plain--southeastern Louisiana, in Deltas in their geologic framework, Houston Geol. Soc., pp. 17-61.

Langhein, W. B. (1961) Salinity and hydrology of closed lakes: U. S. Geol. Surv. Prof. Pap. 412, 20 p.

LaRocque, A. (1960) Molluscan faunas of the Flagstaff formation of central Utah: Geol. Soc. Amer. Mem. 78, pp. 1-100.

Ludlam, S. D. (1967) Sedimentation in Cayuga Lake, NewYork: Limnology and Oceanogr. no. 4, pp. 618-632.

McLeroy, C. A. and Anderson, R. Y. (1966) Laminations of the **Pliocene** Florissant Lake deposits, Colorado: Geol. Soc. Amer. Bull., vol. 77, pp. 605-618.

Morrison, R. B. (1964) Lake Lahontan - Geology of Southern Carson Desert, Nevada: U. S. Geol. Surv. Prof. Pap. 401, 156 p.

Muller, G. (1966) The new Rhine delta in Lake Constance, in Deltas in their geologic framework, Houston Geol. Soc., pp. 107-124.

Murray, R. C. (1969) Hypothesis for the formation of a carbonate-evaporite basin: Geol. Soc. Amer., NE Sec., 4th Ann. Mtg., Abstracts with programs, pp. 42-43.

Neal, J. T. (1965) Geology, mineralogy, and hydrology of U. S. playas: Air Force Res. Lab., Bedford Mass., Environ. Res. Paper, 30 p.

Neev, D. and Emery, K. O. (1967) The Dead Sea: Geol. Surv. Israel Bull., vol. 41, pp. 1-147.

Nelson, G. H. (1967) Sediments of Crater Lake, Oregon: Geol. Soc. Amer. Bull., vol. 78, pp. 833-848.

Nipkow, H. F. (1928) Uber das Verhalten der Skelette plantischer Kieselalgen im geschichteten Tiefenschlamm des Zurich und Baldegersees: Rev. Hydrobiology, vol. 4, pp. 71-120.

Palmer, A. R. (1957) Miocene Anthropods from the Mojave Desert, California: U. S. Geol. Surv. Prof. Pap. 294-G, pp. 237-277.

Picard, M. D. (1957) Criteria used for distinguishing lacustrine and fluvial sediments in Tertiary beds of Uinta Basin, Utah: Jour. Sed. Petrol., vol. 27, pp. 373-377.

------- (1967) Stratigraphy and depositional environments of the Red Peak member of the Chugwater formation (Triassic), west-central Wyoming: Contrib. Geology, vol. 6, pp. 39-67.

------- and High, L. R. (1968) Sedimentary cycles in the Green River formation (Eocene), Uinta Basin, Utah: Jour. Sed. Petrol., vol. 38, pp. 378-383.

Powers, W. E. (1963) The Achanarras Limestone of the Middle Oil Red Sandstone, Caithness, Scotland: Proc. Yorkshire Geol. Soc., vol. 34, pp. 117-138.

Reeves, C. C., Jr. (1968) Introduction to paleolimnology: Developments in sedimentation 11, Elsevier, 228 p.

Rolfe, B. N. (1957) Surficial sediment in Lake Mead: Jour. Sed. Petrol., vol. 27, pp. 378-386.

Rossmann, R. and Callender, E. (1968) Manganese nodules in Lake Michigan: Science, vol. 162, pp. 1123-1124.

------- and ------- (1969) Geochemistry of Lake Michigan manganese nodules: 12th Conf. Great Lakes Res. Proc., pp. 306-316.

Russell, I. C. (1885) Geological history of Lake Lahontan, a Quaternary Lake of northwestern Nevada: U. S. Geol. Surv. Mon. 11, 288 p.

Ruttner, F. (1962) Fundamentals of limnology: Third edition, translated by D. G. and F. E. J. Frey, Univ. of Toronto Press, 295 p.

Sanders, J. E. (1968) Stratigraphy and primary sedimentary structures of fine-grained, well-bedded strata, inferred lake deposits, Upper Triassic, Central and Southern Connecticut: Geol. Soc. Amer. Spec. Pap. 106, pp. 263-305.

Sarmiento, R. and Kirby, R. A. (1962) Recent sediments of Lake Maracaibo: Jour. Sed. Petrol., vol. 32, pp. 698-724.

Schoettle, M. and Friedman, G. M. (1971) Fresh water iron-manganese nodules in Lake George, New York: Geol. Soc. Amer. Bull., vol. 82, pp. 101-110.

Smith, A. J. (1959) Structures in the stratified late-glacial clays of Widermere, England: Jour. Sed. Petrol., vol. 29, pp. 477-543.

Smith, W. O., et al. (1954) Lake Mead comprehensive survey of 1948-49: U. S. Dept. Interior and U. S. Dept. Navy, Advance report, 366 p.

-------, et al. (1960) Comprehensive survey of sedimentation in Lake Mead, 1948-49: U. S. Geol. Surv. Prof. Pap. 295.

Snyder, C. T. and Langbein, W. B. (1962) The Pleistocene Lake in Spring Valley, Nevada, and its climatic implications: Jour. Geol. Res., vol. 67, pp. 2385-2394.

Solohub, J. T. and Klovan, J. E. (1970) Evaluation of grain size parameters in lacustrine environments: Jour. Sed. Petrol., vol. 40, pp. 81-101.

Sommers, L. H. and Josephson, P. D. (1968) Bottom sediments of southwestern Lake Michigan: Inter. Assoc. Great Lakes Res., Proc. 11th Conf., pp. 245-252.

Stokes, W. L., ed. (1966) The Great Salt Lake, Utah: Utah Geol. Soc. Guidebook to Geology of Utah, No. 20.

Stone, R. O'N. (1956) A geologic investigation of playa lakes: Univ. Southern Calif. Thesis (Ph.D.) Unpub., 302 p.

Tanner, W. F. (1968) Shallow lake deposits, lower part of the Morrison formation (Late Jurassic), northern New Mexico: The Mountain Geologist, vol. 5, pp. 187-197.

Trowbridge, A. C. (1911) Terrestrial deposits of Owens Valley, California: Jour. Geol., vol. 19, pp. 706-747.

Twenhofel, W. H. and McKelvey, V. E. (1941) Sediments of fresh water lakes: Amer. Assoc. Petrol. Geol. Bull., vol. 25, pp. 826-849.

Van Houten, F. B. (1944) Stratigraphy of the Wilwood and Tatman Formations in northwestern Wyoming: Geol. Soc. Amer. Bull., vol. 55, pp. 165-210.

------- (1964) Cyclic lacustrine sediments, Upper Triassic Lockatong formation, central New Jersey and adjacent Pennsylvania, in Symposium on cyclic sedimentation, Kansas Geol. Surv. Bull., vol. 169, pp. 497-531.

------- (1965) Composition of Triassic Lockatong and associated formations of the Newark group, central New Jersey and adjacent Pennsylvania: Amer. Jour. Sci., vol. 263, pp. 825-863.

Welten, M. (1944) Pollenanalytische, stratigraphische und geochronologische Untersuchungen aus dem Faulenseemoos bei Spiez: Veroffentl. Geobotan. Inst. Rubel, vol. 21, 1, pp. 1-201.

Wulf, G. R. (1963) Bars, spits and ripplemarks in a Michigan lake: Amer. Assoc. Petrol. Geol. Bull., vol. 47, pp. 691-695.

TERRIGENOUS FAN SYSTEMS -- Summary

1. Included systems are alluvial fan, fan delta, and clastic wedge; similarity of processes and association

   Alluvial fan: cone-shaped pile of sediment built where stream issues from a highland onto an adjacent lowland
   Fan delta: essentially an alluvial fan built into a standing and permanent body of water, characterized by distally associated facies owing to this water body
   Clastic wedge: fan or bajada system; complex of alluvial fans or fan deltas considered with associated marginal facies; convenient term for thick clastic units in rock record generally associated with terminal tectonics, block mountains, etc.

Alluvial Fans

2. General features: Essential requisites are highland and lowland side by side; established by differential erosion (not common) or by tectonic uplift or depression. Best developed in sparsely vegetated areas of low and intermittent rainfall such as Near and Middle East, Australian interior, North American southwest, North American subarctic regions, and European Alps; arid to semi-arid regions

   Most related to aggrading basins, generally without thorough perennial drainage

3. Morphologic features: Concave in longitudinal profile, convex in transverse profile; slope from few feet to a few hundred feet per mile; generally less than 10°; common size of 1/2 mile to 4 miles in length; coalescing of individual fans gives bajadas or alluvial plains extending length of highland range; these oriented parallel to highland with axis of thickness also aligned; fan commonly thickest adjacent to source

4. Morphologic units:

   Fan head: uppermost part of fan at apex
   Proximal fan: upper part of fan
   Distal fan: lower part of fan
   Grade distally into a variety of depositional systems; may persist downslope to braided to meander-belt systems; commonly associated with lake system; eolian modification common; if grade to marine facies, by definition considered a fan delta

5. Processes and deposits: Stream flow (relatively low mud) and debris flow (high muds or fines) and combination of two, though one commonly dominant

   Debris flow:
   Medium is not water but rather mud, which moves as viscous, quasi-plastic material; mud viscosity up to 1,000 poise contrasted

to 0.01 poise for water; density about 2.0 to 2.5 for mud compared to water with suspended load with density just above 1.0

Submergence of fragments of larger size 60% less than in water

Mud flow does not deposit selectively as water; resulting deposits are extremely poorly sorted; conglomerate with varying size gravel and fine grained matrix

Represent maximum sediment discharge onto fan in early stages after torrential rainfall; duration for a few minutes to an hour or so

Generally confined to proximal fan; flow is checked by loss of water to underlying permeable fan sediments or by drying of mud

Main features: very poor sorting; individual units unstratified; quicksand injection features, lack of imbrication of gravels; dominant process if muds or fines available from source area

Stream flow:

May occur in channels (confined) or as sheetfloods (unconfined)

Dominant process on fans where fines not available and debris flows cannot form

Commonly follows mudflows after fines in source area have been carried out

Duration of hours or weeks

Loss of stream competence on fan due to decrease in slope along fan radially and loss of gradient; loss of water to underlying permeable fan sediments; change from confined channel in upper part of fan to unconfined channel below mid-fan; downfan loss of competence leads to size gradation, coarsest in upper part, fines carried to distal part of fan

Channel flow exclusively braided (high load, high sand, high gradient); dominant deposit is longitudinal bar; water-laid gravels commonly imbricated

Sieve deposition and infiltration:

Special case of stream flow deposits involving water infiltration into underlying permeable fan sediments

Deposit in form of coarse grained lobe; causes damming of channel with upstream slope behind dam, channel backfilled with finer grained sediments; coarser materials stacked over permeable, coarse sieve lobe

6. Fan sediments:

Composition: large gravels, immature sediments due to proximity of source area and depositional site, little or no reworking; arkoses and graywackes

Downfan decrease in grain size, but only in general sense

Overall very poor sorting, debris flows poorest, water-laid deposits little better

Downfan increase in roundness

Fan Deltas

7. Processes similar to arid-region alluvial fans; differ in that distal part is built into standing body of water, commonly marine; destructional bars developed along distal margin; delta features include only progradation into standing body of water; main processes of fan origin

Clastic Wedge System

8. Numerous examples of thick gravel-bearing sequences in ancient record; have in common a tectonic association; most are bounded by highland fault with faulting contemporaneous

   Gravel and coarsest materials proximal to front and grading in a relatively short distance through finer grained clastics and then into facies of other systems; maximum thickness next to source, commonly thin away from source and bounding fault at rate of 500 to 1,000 feet per mile. Persistent in linear belt.

9. Ancient examples: Newark and related systems of eastern North America (Triassic); New Red Sandstone of southern England (Triassic); Paleozoic Appalachian wedges (Catskill, Bloomsburg, Queenston); Old Red Sandstone (Devonian) of Wales; Mid-continent Pennsylvanian (Arbuckles, Wichitas, Criner Hills, Ouachitas); Central and southern Rockies (Upper Paleozoic) (Front Rangia, Unconpahgre)

10. Mineral reservoirs: Alluvial fans are not known to produce oil and gas; they are, however, the major source of base metal placers. Fan deltas, by contrast, especially the marginal destructive marine bars, are highly productive of oil and gas in many basins of the world.

FANS, FAN-DELTA & CLASTIC WEDGE SYSTEMS

Selected References

Allen, J. R. L. (1965) A review of the origin and characteristics of recent alluvial sediments: Sedimentology, vol. 5, pp. 89-191.

------- (1965) The sedimentation and paleogeography of the Old Red Sandstone of Anglesey, North Wales: Proc. Yorkshire Geol. Soc., vol. 35, pp. 139-187.

------- and Friend, P. F. (1968) Deposition of the Catskill facies, Appalachian region: with notes on some other Old Red Sandstone basins: Geol. Soc. Amer. Spec. Paper 106, pp. 21-74.

Beaty, C. B. (1963) Origin of alluvial fans, White Mountains, California and Nevada: Assoc. Amer. Geogr. Annals, vol. 53, pp. 516-535.

------- (1970) Age and estimated rate of accumulation of an alluvial fan, White Mountains, California, U.S.A.: Amer. Jour. Sci., vol. 268, pp. 50-77.

Belt, E. S. (1968) Carboniferous continental sedimentation, Atlantic Provinces, Canada: Geol. Soc. Amer. Spec. Paper 106, pp. 127-176.

Blackwelder, Eliot (1928) Mudflow as a geologic agent in semiarid mountains: Bull. Geol. Soc. Amer., vol. 39, pp. 465-480.

------- (1931) Desert plains: Jour. Geology, vol. 39, pp. 133-140.

Blissenback, E. (1954) Geology of alluvial fans in semiarid regions: Bull. Geol. Soc. Amer., vol. 65, pp. 175-189.

Bolyard, D. W. (1959) Pennsylvanian and Permian stratigraphy in Sangre de Cristo Mountains between La Veta Pass and Westcliffe, Colorado: Bull. Amer. Assoc. Petrol. Geol., vol. 43, pp. 1896-1939.

Brosco, A. J., and Thomson, S. (1969) Observations on an alpine mudflow, Steele Creek, Yukon: Canadian Jour. Earth Sci., vol. 6, no. 2, pp. 219-229.

Bryan, K. (1922) Erosion and sedimentation in the Papago Country, Arizona: Bull. U. S. Geol. Survey, no. 730, pp. 19-90.

Bull, W. B. (1962) Relation of textural (CM) patterns to depositional environments of alluvial fan deposits: Jour. Sed. Petrology, vol. 32, pp. 211-217.

------- (1963) Alluvial-fan deposits in western Fresno County, California: Jour. Geology, vol. 71, pp. 243-250.

Burke, K. (1967) The Yallahs Basin: a sedimentary basin southeast of Kingston, Jamaica: Marine Geology, vol. 5, pp. 5-60.

Chawner, W. D. (1935) Alluvial fan flooding: the Montrose California, flood of 1934: Geograph. Review, vol. 25, pp. 255-263.

Conrey, B. L. (1967) Early Pleistocene sedimentary history of the Los Angeles Basin, California: Calif. Div. Mines Spec. Rept. 93, pp. 5-63.

Curray, R. R. (1966) Observations of alpine mudflows in the Tenmile Range, Central Colorado: Bull. Geol. Soc. Amer., vol. 77, pp. 771-776.

Denny, C. S. (1964) Alluvial fans in the Death Valley region, California and Nevada: U. S. Geol. Soc. Prof. Paper 466, 59 pp.

------- (1967) Fans and pediments: Amer. Jour. Sci., vol. 265, pp. 81-105.

Eckis, R. (1928) Alluvial fans of the Cucamonga district, southern California: Jour. Geology, vol. 36, pp. 224-247.

Edwards, A. R. (1959) Facies changes in Pennsylvanian rocks along north flank of Wichita Mountains, in Petroleum geology of southern Oklahoma: Amer. Assoc. Petrol. Geol., Tulsa, vol. 2, pp. 142-155.

Friedman, G. M. and Johnson, K. G. (1966) The Devonian Catskill deltaic complex of New York, type example of "tectonic delta complexes," in Deltas in their geologic framework: Houston Geol. Soc., Houston, pp. 171-188.

Fryxell, F. M. and Horberg, Leland (1943) Alpine mudflows in Grand Teton National Park, Wyoming: Bull. Geol. Soc. Amer., vol. 54, pp. 457-472.

Gale, C. U. and Chitale, S. U. (1966) Inland delta building activity of Kosi River: Jour. Hydraulics Div., Proc. Amer. Soc. Civil Engrs., vol. 92, pp. 111-126.

Gilbert, G. K. (1890) Lake Bonneville: U. S. Geol. Soc., Mon. 1, 438 pp.

Gilluly, J. (1946) The Ajo mining district, Arizona: U. S. Geol. Soc. Prof. Paper 209, 112 pp.

Goreau, T. and Burke, K. (1966) Pleistocene and Holocene geology of the island shelf near Kingston, Jamaica: Marine Geology, vol. 4, pp. 207-225.

Ho, C. S. (1969) Some stratigraphic-structural problems of the Linkou Terrace in northern Taiwan: Proc. Geol. Soc. China, vol. 12, pp. 65-80.

Holmes, A. (1965) Principles of physical geology: 2nd edition, The Ronald Press Co., New York, N. Y., 1288 pp.

Hooke, R. LeB. (1967) Processes on arid-region alluvial fans: Jour. Geology, vol. 75, pp. 438-460.

Hoppe, G. and Ekman, S. R. (1964) A note on the alluvial fans of Ladtjovagge, Swedish Lapland: Geograph. Ann., vol. 46, pp. 388-442.

Hubert, J. F. (1960) Petrology of the Fountain and Lyons Formations, Front Range, Colorado: Quarterly, Colo. School of Mines, vol. 55, no. 1, 242 pp.

Jahns, R. H. (1949) Desert floods: Eng. and Sci. Jour., vol. 12, pp. 10-14.

Kidson, C. (1953) The Exmoor Storm and the Lynmouth floods: Geolography?, vol. 38, pp. 1-9.

Klein, G. dV. (1968) Sedimentology of the Triassic rocks in the Lower Connecticut Valley: Geol. Survey Conn., Guidebook no. 2, pp. C-1, 1-19.

Krynine, P. D. (1940) Petrology and genesis of the Third Bradford Sand: Penn. State Coll. Bull., Min. Indust. Exp. Sta. Bull. 29, 134 pp.

------- (1950) Petrology, stratigraphy, and origin of the Triassic sedimentary rocks of Connecticut: Conn. Geol. and Nat. Hist. Survey, Bull. 73, 239 pp.

Laming, D. J. C. (1966) Imbrication paleocurrents, and other sedimentary features in the Lower New Red Sandstone, Devonshire, England: Jour. Sed. Petrology, vol. 36, pp. 940-959.

Lee, C. W. (1969) Petrology and origin of the Linkou Gravel in Taipei, Taiwan, China: Proc. Geol. Soc. China, vol. 12, pp. 49-64.

Legget, R. F., et al. (1966) Alluvial fan formation near Aklavik, Northwest Territories, Canada: Bull. Geol. Soc. Amer., vol. 77, pp. 15-30.

Mallory, W. W. (1958) Pennsylvanian coarse arkosic redbeds and associated mountains, in Symposium on Pennsylvanian rocks of Colorado and adjacent areas: Rocky Mountain Assoc. Geol., pp. 17-20.

McGowen, J. H. (1969) Geology and origin of Gum Hollow Fan Delta, Nueces Bay, Texas: Ph.D. Dissertation, Univ. of Texas.

Leopold, L. B. and Miller, J. P. (1956) Ephemeral streams - hydraulic factors and their relationship to the drainage net: U. S. Geol. Soc. Prof. Paper 282-A, pp. 1-36.

Lonens, P. J. and Thronson, R. C. (1955) Geology of finegrained alluvial deposits in Sacramento Valley and their relationship to seepage, in Banks (ed.), Seepage Conditions in Sacramento Valley: Rept. Water Proj. Authority Calif., pp. Ai-A26.

McKee, E. D. (1957) Primary structures in some recent sediments (U.S. and Mexico): Bull. Amer. Assoc. Petrol. Geol., vol. 41, pp. 1704-1747.

Meckel, L. D. (1967) Origin of Pottsville Conglomerates (Pennsylvanian) in the central Appalachians: Bull. Geol. Soc. Amer., vol. 78, pp. 223-258.

Melton, M. A. (1965) The geomorphic and paleoclimatic significance of alluvial deposits in southern Arizona: Jour. Geology, vol. 73, pp. 1-38.

Murray, H. F. (1958) Pennsylvanian stratigraphy of the Maroon trough, in Symposium on Pennsylvanian rocks of Colorado and adjacent areas: Rocky Mount. Assoc. Geol., pp. 47-58.

Nilsen, T. H. (1968) The relationship of sedimentation to tectonics in the Solund Devonian District of southwestern Norway: Norges Geologiske Undersøkelse, Nr. 259, 108 pp.

------- (1969) Old Red sedimentation in the Buelandet-Vaerlandet Devonian district, Western Norway: Sed. Geol., vol. 3, pp. 35-57.

Ruhe, R. V. (1964) Landscape morphology and alluvial deposits in southern New Mexico: Ann. Assoc. Amer. Geograph., vol. 54, pp. 147-159.

Smith, N. D. (1970) The braided stream depositional environment: comparison of the Platte River with some Silurian clastic rocks, north-central Appalachians: Bull. Geol. Soc. Amer., vol. 81, pp. 2993-3014.

Stanton, R. J. (1967) The effects of provenance and basin-edge topography on sedimentation in the Basal Castaic Formation (Upper Miocene, Marine) Los Angeles County, California: Calif. Div. Mines Rept. 92, pp. 21-31.

Thompson, R. W. (1965) Tidal flat sedimentation on the Colorado River Delta, northwest Gulf of California: Wyoming Geol. Assoc. Guidebook, pp. 188-190.

Tomlinson, C. W. and McBee, W., Jr. (1959) Pennsylvanian sediments and orogenies of Ardmore district, Oklahoma, in Petroleum geology of southern Oklahoma, vol. 2, Tulsa, pp. 3-52.

Trowbridge, A. C. (1911) Terrestrial deposits of Owens Valley, California: Jour. Geology, vol. 19, pp. 706-747.

Walker, T. R. and Thompson, R. W. (1968) Late Quaternary geology of the San Felipe area, Baja California, Mexico: Jour. Geology, vol. 76, pp. 479-485.

Wilson, M. D. (1970) Upper Cretaceous-Paleocene synorogenic conglomerates of southwestern Montana: Bull. Amer. Assoc. Petrol. Geol., vol. 54, pp. 1843-1867.

Woodford, A. O. (1925) The San Onofre Breccia: Calif. Univ. Dept. Geol. Sci. Bull., vol. 15, pp. 159-280.

ADDENDUM

McGowen, J.H. (1970) Gum Hollow Fan Delta, Nueces Bay, Texas, Univ. Texas Bur. Econ. Geology Rept. Invest. No. 69, 91 pp.

-------and Groat, C.G. (1971) Van Horn Sandstone, West Texas: an alluvial fan model for mineral exploration, Univ. Texas Bur. Econ. Geology Rept. Invest. No. 72, 57 pp.

GENERAL

Updated References

Le Blanc, R. J. (1972) Geometry of sandstone reservoir bodies: *in* Underground waste management and environmental implications, Am. Assoc. Petrol. Geol. Mem. 18, pp. 113-190.

MacKenzie, D. G. (1972) Primary stratigraphic traps in sandstone: *in* Stratigraphic oil and gas fields -- classification, exploration methods, and case histories: Am. Assoc. Petrol. Geol. Mem. 16, pp. 47-63.

Reineck, H. E., and Singh, I. B. (1973) Depositional sedimentary environments: Springer-Verlag, New York, 439 pp.

Shelton, J. W. (1973) Models of sand and sandstone deposits: A methodology for determining sand genesis and trend: Oklahoma Geol. Survey Bull. 118, 122 pp.

FLUVIAL DEPOSITIONAL SYSTEMS

Updated References

Cant, D. J. (1973) Devonian braided stream deposits in the Battery Point Formation, Gaspe Est, Quebec: Maritime Sediments, v. 9, pp. 13-20.

Costello, W. R., and Walker, R. G. (1972) Pleistocene sedimentology, Credit River, Southern Ontario, a new component of the braided river model: Jour. Sed. Petrology, v. 42, pp. 389-400.

Epstein, J. B., and Epstein, A. G. (1972) The Shawangunk Formation (Upper Ordovician (?) to Middle Silurian) in eastern Pennsylvania: U. S. Geol. Surv. Prof. Paper 744, 45 pp.

Handy, R. L. (1972) Alluvial cutoff dating from subsequent growth of a meander: Bull. Geol. Soc. Amer., v. 83, pp. 475-480.

Jacob, A. F. (1973) Depositional environments of Paleocene Tongue River Formation, western North Dakota: Bull. Amer. Assoc. Petrol. Geol., v. 57, pp. 1038-1052.

Jonker, R. K. (1972) Fluvial sediments of Cretaceous age along the southern border of the Cantabrian Mountains, Spain: Leidse Geol. Meded., v. 48, pp. 275-379.

Leeder, Michael (1973) Sedimentology and paleogeography of the Upper Old Red Sandstone in the Scottish Border Basin: Scottish Jour. Geol., v. 9, pp. 117-144.

Lumsden, D. N., *et al*. (1971) Sedimentation and petrology of Spiro and Foster sands (Pennsylvanian), McAlester Basin, Oklahoma: Bull. Amer. Assoc. Petrol. Geol., v. 55, pp. 254-266.

Rust, B. R. (1972) Structure and process in a braided river: Sedimentology, v. 18, pp. 221-245.

Smith, N. D. (1972) Some sedimentological aspects of planar cross-stratification in a sandy braided river: Jour. Sed. Petrology, v. 42, pp. 624-634.

Williams, G. E. (1971) Flood deposits of the sand-bed ephemeral streams of central Australia: Sedimentology, v. 17, pp. 1-40.

DELTA SYSTEMS

Updated References

Arndorfer, D. J. (1973) Discharge patterns in two crevasses of the Mississippi River Delta: Marine Geology, v. 15, pp. 269-287.

Baldwin, E. J. (1973) The Moenkopi Formation of north-central Arizona: an interpretation of ancient environments based on sedimentary structures and stratification types: Jour. Sed. Petrology, v. 43, pp. 92-106.

Blakey, R. C. (1973) Stratigraphy and origin of the Moenkopi Formation (Triassic) of southeastern Utah: Mountain Geologist, v. 10, pp. 1-17.

Brink, A. H. (1974) Petroleum geology of Gabon Basin: Bull. Amer. Assoc. Petrol. Geol., v. 58, pp. 216-235.

Busch, D. A. (1971) Genetic units in delta prospecting: Bull. Amer. Assoc. Petrol. Geol., v. 55, pp. 1137-1154.

Carrigy, M. A. (1971) Deltaic sedimentation in Athabasca tar sands Bull. Amer. Assoc. Petrol. Geol., v. 55, pp. 1155-1169.

Clark, R. H. and Rouse, J. T. (1971) A closed system for generation and entrapment of hydrocarbons in Cenozoic deltas, Louisiana Gulf Coast: Bull. Amer. Assoc. Petrol. Geol., v. 55, pp. 1170-1178.

Conolly, J. R. and Ferm, J. C. (1971) Permo-Triassic sedimentation patterns, Sydney Basin, Australia: Bull. Amer. Assoc. Petrol. Geol., v. 55, pp. 2018-2032.

Donaldson, A. C., et al. (1970) Holocene Guadalupe delta of Texas Gulf Coast: Soc. Econ. Pal. Min. Spec. Pub. 15, pp. 107-137.

Flores, R. M. (1972) Delta front - delta plain facies of the Pennsylvanian Haymond Formation, northeastern Marathon Basin, Texas: Bull. Geol. Soc. Amer., v. 83, pp. 3415-3424.

Gagliano, S. M. and Van Beek, J. L. (1970) Geologic and geomorphic aspects of deltaic processes: L. S. U., Coastal Studies Institute, Hydrologic and Geologic Studies of Coastal Louisiana, v. 1, 140 pp.

Hoyt, J. H. and Henry, V. J., Jr. (1971) Origin of capes and shoals along the southeastern coast of the United States: Bull. Geol. Soc. Amer., v. 82, pp. 59-66.

Jansa, Lubomir (1972) Depositional history of the coal-bearing Upper Jurassic - Lower Cretaceous Kootenay Formation, Southern Rocky Mountains, Colorado: Bull. Geol. Soc. Amer., v. 83, pp. 3199-3222.

Laury, R. L. (1971) Stream bank failure and rotational slumping: preservation and significance in the geologic record: Bull. Geol. Soc. Amer. v. 82, pp. 1251-1266.

Lawyer, G. F. (1972) Sedimentary features and paleoenvironment of the Dakota Sandstone (Early Upper Cretaceous) near Hanksville, Utah: Brigham Young Univ. Geology Studies, v. 19, pt. 2, pp. 89-120.

Link, M. H. (1972) Matilija Sandstone: a transition from deep-water flysch to shallow-marine deposition: Soc. Econ. Pal. Min. Pacific Sect., Guidebook, Spring Field Trip, pp. 30-36.

MacKenzie, D. B. (1971) Post-Lytle Dakota Group on west flank of Denver Basin, Colorado: Mountain Geologist, v. 8, pp. 91-131.

Manka, L. L. and Steinmetz, Richard (1971) Sediments and depositional history of the southeast lobe of the Colorado River Delta, Texas: Gulf Coast Assoc. Geol. Soc. Trans., v. 21, pp. 309-323.

Martini, I. P. (1971) Regional analysis of sedimentology of Medina Formation (Silurian), Ontario and New York: Bull. Amer. Assoc. Petrol. Geol., v. 55, pp. 1249-1261.

Mazzulo, S. J. (1973) Deltaic depositional environments in the Hamilton Group (Middle Devonian), southeastern New York State: Jour. Sed. Petrology, v. 43, pp. 1061-1071.

Owens, J. P. and Sohl, N. F. (1969) Shelf and deltaic paleoenvironments in the Cretaceous-Tertiary formations of the New Jersey coastal plain: pp. 235-278 in Subitzky, S., editor, Geology of Selected Areas in New Jersey and Eastern Pennsylvania and Guidebook of Excursions: Rutgers Univ. Press, New Brunswick, N. J.

Pezzetta, J. M. (1973) The St. Clair River delta: sedimentary characteristics and depositional environments: Jour. Sed. Petrology, v. 43, pp. 168-187.

Shannon, J. P., Jr., and Dahl, A. R. (1971) Deltaic stratigraphic traps in West Tuscola Field, Taylor County, Texas: Bull. Amer. Assoc. Petrol. Geol., v. 55, pp. 1194-1205.

Shepheard, W. W., and Hills, L. V. (1970) Depositional environments, Bearpaw-Horseshoe Canyon (Upper Cretaceous) transition zone Drumheller "Badlands," Alberta: Bull. Canadian Petrol. Geol., v. 18, pp. 166-215.

Terrell, F. M. (1972) Lateral Facies and paleoecology of Permian Elephant Canyon Formation, Grand County, Utah: Brigham Young Univ. Geol. Studies, v. 19, pt. 2, pp. 3-44.

Terwindt, J. H. J. (1973) Sand movement in the in- and offshore tidal area of the southwestern part of The Netherlands: Geol. en Mijnbouw, v. 52, pp. 69-77.

Van de Graaff, F. R. (1972) Fluvial-deltaic facies of the Castlegate Sandstone (Cretaceous), east-central Utah: Jour. Sed. Petrology, v. 42, pp. 558-571.

Visher, G. S., and others. (1971) Pennsylvanian delta patterns and petroleum occurrences in eastern Oklahoma: Bull. Amer. Assoc. Petrol. Geol., v. 55, pp. 1206-1230.

Walker, R. G. (1971) Nondeltaic depositional environments in the Catskill clastic wedge (Upper Devonian) of central Pennsylvania: Bull. Geol. Soc. Amer., v. 82, pp. 1305-1326.

Walker, R. G., and Harms, J. C. (1971) The "Catskill Delta": a prograding muddy shoreline in central Pennsylvania: Jour. Geol., v. 79, pp. 381-399.

Weber, K. J. (1971) Sedimentological aspects of oil fields in the Niger Delta: Geol. en Mijnbouw, v. 50, pp. 559-576.

Weimer, R. J. (1973) A guide to uppermost Cretaceous stratigraphy central Front Range, Colorado: deltaic sedimentation, growth faulting, and early Laramide crustal movement: Mountain Geologist, v. 10, pp. 53-97.

Woodbury, H. O., and others. (1973) Pliocene and Pleistocene depocenters, outer continental shelf, Louisiana and Texas: Bull. Amer. Assoc. Petrol. Geol., v. 57, pp. 2428-2439.

Wright, L. D., and Coleman, J. M. (1973) Variations in morphology of major river deltas as functions of ocean wave and river discharge regimes: Bull. Amer. Assoc. Petrol. Geol., v. 57, pp. 370-398.

Wright, L. D., Coleman, J. M., Thom, B. G. (1973) Processes of channel development in a high-tidal range environment: Cambridge Gulf-Ord River delta, western Australia: Jour. Geol., v. 81, pp. 15-41.

Updated References

Allen, G. P. (1971) Relationship between grain size parameter distribution and current patterns in the Gironde estuary (France): Jour. Sed. Petrology, v. 41, pp. 74-88.

Campbell, C. V., and Oaks, R. Q., Jr. (1973) Estuarine sandstone filling tidal scours, Lower Cretaceous Fall River Formation, Wyoming: (no reference listed)

Gellatly, D. C. (1970) Cross-bedded tidal megaripples from King Sound (Northwestern Australia): Sedimentary Geology, v. 4 pp. 185-191.

Howard, J. D., and Frey, R. W. (1973) Characteristic physical and biogenic sedimentary structures in Georgia estuaries: Bull. Amer. Assoc. Petrol. Geol., v. 57, pp. 1169-1184.

Jones, A. S. G. (1971) A textural study of marine sediments in a portion of Cardigan Bay (Wales): Jour. Sed. Petrology, v. 41, pp. 505-516.

Oertel, G. F. (1972) Sediment transport of estuary entrance shoals and the formation of swash platforms: Jour. Sed. Petrology, v. 42, pp. 857-863.

Oertel, G. F. (1973) Examination of textures and structures of mud in layered sediments at the entrance of a Georgia tidal inlet: Jour. Sed. Petrology, v. 43, pp. 33-41.

Phleger, F. B., and Ayala-Castanares, A. (1971) Processes and history of Terminos Lagoon, Mexico: Bull. Amer. Assoc. Petrol. Geol., v. 55, pp. 2130-2140.

Raaf, J. F. M. de, and Boersma, J. R. (1971) Tidal deposits and their sedimentary structures (seven examples from western Europe): Geol. en Mijnbouw, v. 50, pp. 479-504.

Terwindt, J. H. J. (1971) Lithofacies of inshore estuarine and tidal-inlet deposits: Geol. en Mijnbouw, v. 50, pp. 515-526.

Van Beek, J. L., and Koster, E. A. (1972) Fluvial and estuarine sediments exposed along the Oude Maas (The Netherlands): Sedimentology, v. 19, pp. 237-256.

Wiedemann, H. V. (1972) Shell deposits and shell preservation in Quaternary and Tertiary estaurine sediments in Georgia: Sedimentary Geology, v. 7, pp. 103-125.

Wright, L. D., and others (1972) Water-mass stratification and bed form characteristics in East Pass, Destin, Florida: Marine Geology, v. 12, pp. 43-58.

BEACH AND BARRIER SYSTEMS

Updated References

Clifton, H. E., Hunter, R. E., and Phillips, R. L. (1971) Depositional structures and processes in the non-barred high-energy nearshore: Jour. Sed. Petrology, v. 41, pp. 651-670.

Campbell, C. V. (1971) Depositional model - Upper Cretaceous Gallup beach shoreline, Ship Rock area, New Mexico: Jour. Sed. Petrology, v. 41, pp. 395-409.

Cook, D. O., and Gorsline, D. S. (1972) Field observations of sand transport by shoaling waves: Marine Geology, v. 13, pp. 31-55.

Cook, P. J., and Polach, H. A. (1973) A chenier sequence at Broad Sound, Queensland, and evidence against a Holocene high sea level: (no reference given)

Davies, D. K. and others. (1971) Recognition of barrier environments: Bull. Amer. Assoc. Petrol. Geol., v. 55, pp. 550-565.

Davis, R. A., Jr., and Fox, W. T. (1972) Coastal processes and sand bars: Jour. Sed. Petrology, v. 42, pp. 401-412.

Davis, R. A., Jr., and others. (1972) Comparison of ridge and runnel systems in tidal and non-tidal environments: Jour. Sed. Petrology, v. 42, pp. 413-421.

Dickinson, K. A., and others. (1972) Criteria for recognizing ancient barrier coastlines: pp. 192-214 in Rigby, J. K., and Hamblin, W. K., editors, Recognition of Ancient Sedimentary Environments: Soc. Econ. Pal. Min. Spec. Publ. No. 16.

Goldring, Roland, and Bridges, Paul (1973) Sublittoral sheet sandstones: Jour. Sed. Petrology, v. 43, pp. 736-747.

Howard, J. D., and others (1972) Georgia coastal region, Sapelo Island, U. S. A.: Sedimentology and Biology: Senckenbergiana Maritime, v. 4, 222 pp.

Kraft, J. C. (1971) Sedimentary facies patterns and geologic history of a Holocene marine transgression: Bull. Geol. Soc. Amer., v. 82, pp. 2131-2158.

Land, C. B., Jr. (1972) Stratigraphy of Fox Hills Sandstone and associated formations, Rock Springs uplift and Wamsutter Arch area, Sweetwater County, Wyoming: a shoreline-estuary sandstone model for the Late Cretaceous: Colo. Sch. Mines Quart., v. 67, No. 2, 69 pp.

Niedoroda, A. W. (1972) Waves, currents, sediments and sand bars associated with low energy coastal environments: Gulf Coast Assoc. Geol. Soc., Trans., v. 22, pp. 229-239.

Stapor, Frank (1973) History and sand budgets of the barrier island system in the Panama City, Florida, region: Marine Geology, v. 14, pp. 277-286.

Terwindt, J. H. J., and Breusers, H. N. C. (1972) Experiments on the origin of flaser, lenticular, and sand-clay alternating bedding: Sedimentology, v. 19, pp. 85-98.

Tyler, J. H. (1972) Pigeon Point Formation: an Upper Cretaceous shoreline succession, central California coast: Jour. Sed. Petrology, v. 42, pp. 537-557.

TIDAL FLAT SYSTEMS

Updated References

Epstein, J. B., and Epstein, A. G. (1969) Geology of the Valley and Ridge province between Delaware Water Gap and Lehigh Gap, Pennsylvania: pp. 132-205 in Subitzky, S., editor, Geology of Selected Areas in New Jersey and Eastern Pennsylvania and Guidebook of Excursions, Rutgers Univ. Press, New Brunswick, N. J.

Klein, G. deV. (1971) A sedimentary model for determining paleo-tidal range: Bull. Geol. Soc. Amer., v. 82, pp. 2585-2592.

MacKenzie, D. B. (1972) Tidal sand flat deposits in Lower Cretaceous Dakota Group near Denver, Colorado: Mountain Geologist, v. 9 pp. 269-277.

SHELF SYSTEMS

Updated References

Banks, N. L. (1973) Tide-dominated offshore sedimentation, Lower Cambrian, north Norway: Sedimentology, v. 20, pp. 213-228.

Brenner, R. L., and Davies, D. K. (1974) Oxfordian sedimentation in western interior United States: Bull. Amer. Assoc. Petrol. Geol., v. 58, pp. 407-428.

Dobson, M. R., and others. (1971) The sediment on the floor of the southern Irish Sea: Marine Geology, v. 11, pp. 27-69.

Emery, K. O., and Uchupi, E. (1972) Western North Atlantic Ocean: topography, rocks, structure, water, life, and sediments: Amer. Assoc. Petrol. Geol., Tulsa, Okla., 532 pp.

Exum, F. A. (1973) Lithologic gradients in marine bar, Cadeville Sand, Calhoun Field, Louisiana: Bull. Amer. Assoc. Petrol. Geol., v. 57, pp. 301-320.

Frank, W. M., and Friedman, G. M. (1973) Continental-shelf sediments off New Jersey: Jour. Sed. Petrology, v. 43, pp. 224-237.

Gibbs, R. J. (1973) The bottom sediments of the Amazon shelf and tropical Atlantic Ocean: Marine Geology, v. 14, pp. M39-M45.

Heckel, P. H. (1972) Recognition of ancient shallow marine environments, pp. 226-286 in Rigby, J. K., and Hamblin, W. K., editors, Recognition of Ancient Sedimentary Environments, Soc. Econ. Pal. Min. Spec. Publ. No. 16.

Kenyon, N. H. (1970) Sand ribbons of European tidal seas: Marine Geology, v. 9, pp. 25-39.

McCave, I. N. (1971) Wave effectiveness at the sea bed and its relationship to bed-forms and deposition of mud: Jour. Sed. Petrology, v. 41, pp. 89-96.

McCave, I. N. (1973) The sedimentology of a transgression: Portland Point and Cooksburg Members (Middle Devonian), New York State: Jour. Sed. Petrology, v. 43, pp. 484-504.

McLennen, C. E. (1973) New Jersey continental shelf near bottom current meter records and recent sediment activity: Jour. Sed. Petrology, v. 43, pp. 371-380.

McMaster, R. L., and others. (1971) Continental shelf and upper slope sediments off Portuguese Guinea, Guinea, and Sierra Leone, West Africa: Jour. Sed. Petrology, v. 41, pp. 150-158.

Michaelis, E. R., and Dixon, G. (1969) Interpretation of depositional processes from sedimentary structures in the Cardium Sand: Bull. Canadian Petroleum Geol., v. 17, pp. 410-443.

Milliman, J. D., and others (1972) Sediments of the Continental Margin off the eastern United States: Bull. Geol. Soc. Amer., v. 83, pp. 1315-1334.

Stride, A. H. (1973) Sediment transport by the North Sea: pp. 101-130 in Goldberg, E. D., editor, North Sea Science, M. I. T. Press, Cambridge, Mass.

Swift, D. J. P., and others (1972) Anatomy of a short face ridge system, False Cape, Virginia: Marine Geology, v. 12, pp. 59-84.

Swift, D. J. P. (1973) Ridge and swale topography of the Middle Atlantic Bight, North America: secular response to the Holocene hydraulic regime: Marine Geology, v. 15, pp. 227-247.

SLOPE AND ABYSSAL SYSTEMS

Updated References

Bartolini, C., and others. (1972) Morphology and Recent sediments of the western Alboran Basin in the Mediterranean Sea: Marine Geology, v. 13, pp. 159-224.

Beck, R. H., and Lehner, P (1974) Oceans, new frontier in exploration: Bull. Amer. Assoc. Petrol. Geol., v. 58, pp. 376-395.

Bouma, A. H. (1972) Fossil contourites in lower Niesenflysch, Switzerland: Jour. Sed. Petrology, v. 42, pp. 917-921.

Burke, Kevin (1972) Longshore drift, submarine canyons, and submarine fans in development of Niger delta: Bull. Amer Assoc. Petrol. Geol., v. 56, pp. 1975-1983.

Chamberlain, C. K. (1971) Bathymetry and paleoecology of Ouachita geosyncline of southeastern Oklahoma as determined from trace fossils: Bull. Amer. Assoc. Petrol. Geol., v. 55, pp. 34-50.

Chipping, D. H. (1972) Sedimentary structure and environment of some thick sandstone beds of turbidite type: Jour. Sed. Petrology, v. 42, pp. 587-595.

Corbett, K. D. (1972) Features of thick-bedded sandstones in a proximal flysch sequence, Upper Cambrian, southwest Tasmania: Sedimentology, v. 19, pp. 99-114.

Corbett, K. D. (1973) Open-cast slump sheets and their relationship to sandstone beds in an Upper Cambrian flysch sequence, Tasmania: Jour. Sed. Petrology, v. 43, pp. 147-159.

Crimes, T. P. (1973) From limestones to distal turbidites: a facies and trace fossil analysis in the Zumaya flysch (Paleocene-Eocene), north Spain: Sedimentology, v. 20, pp. 105-131.

Davies, D. K. (1972) Mineralogy, petrography, and derivation of sands and silts of the continental slope, rise, and abyssal plain of the Gulf of Mexico: Jour. Sed. Petrology, v. 42, pp. 59-65.

Davies, D. K. (1972) Deep sea sediments and their sedimentation, Gulf of Mexico: Bull. Amer. Assoc. Petrol. Geol., v. 56, pp. 2212-2239.

DuPlessis, A., and others. (1972) Shallow structure of the continental margin of southwestern Africa: Marine Geology, v. 13, pp. 77-89.

Elter, P. and Trevisan, L. (1973) Olistostromes in the tectonic evolution of the Northern Apennines: pp. 175-188 in DeJong, K. A., and Sholten, R., editors, Gravity and Tectonics, John Wiley and Sons, New York.

Ewing, M. and others. (1973) Sediment distribution in the oceans: the Atlantic: Bull. Geol. Soc. Amer., v. 84, pp. 71-88.

Field, M. E., and Pilkey, O. H. (1971) Deposition of deep-sea sands: comparison of two areas of the Carolina continental rise: Jour. Sed. Petrology, v. 41, pp. 526-536.

Fisher, R. V. (1971) Features of coarse-grained, high-concentration fluids and their deposits: Jour. Sed. Petrology, v. 41, pp. 916-927.

Gealy, E. L. (1971) Results of the JOIDES deep sea drilling project: 1968-1971: Eighth World Petroleum Congress, Proceedings, v. 2, pp. 337-348.

Hamilton, E. L. (1973) Marine geology of the Aleutian Abyssal Plain: Marine Geology, v. 14, pp. 295-325.

Hamilton-Smith, Terence (1971) A proximal-distal turbidite sequence and a probable submarine canyon in the Siegas Formation (Early Llandovery) of northwestern New Brunswick: Jour. Sed. Petrology, v. 41, pp. 752-762.

Hampton, M. A. (1972) The role of subaqueous debris flow in generating turbidity currents: Jour. Sed. Petrology, v. 42, pp. 775-793.

Haner, B. E. (1971) Morphology and sediments of Redondo submarine fan, southern California: Bull. Geol. Soc. Amer., v. 82, pp. 2413-2432.

Hendry, H. E. (1972) Breccias deposited by mass flow in the Breccia Nappe of the French pre-Alps: Sedimentology, v. 18, pp. 277-292.

Hendry, H. E. (1973) Sedimentation of deep water conglomerates in Lower Ordovician rocks of Quebec -- composite bedding produced by progressive liquefaction of sediment?: Jour. Sed. Petrology, v. 43, pp. 125-136.

Hollister, C. D., and Heezen, B. C. (1972) Geologic effects of ocean bottom currents: western North Atlantic: pp. 37-66 in Gordon, A. L., editor, Studies in Physical Oceanography, v. 2, Gordon and Breach, Publishers, New York.

Horn, D. R., and others. (1971) Turbidites of the Hatteras and Sohm abyssal plains, western North Atlantic: Marine Geology, v. 11, pp. 287-323.

Horn, D. R., and others. (1971) Turbidites of the northwest Pacific: Sedimentology, v. 16, pp. 55-69.

Horn, D. R., Ewing, J. I., and Ewing, M. (1972) Graded-bed sequences emplaced by turbidity currents north of 20°N in the Pacific, Atlantic, and Mediterranean: Sedimentology, v. 18, pp. 247-275.

Kraft, J. C., and others. (1971) Time-stratigraphic units and petroleum entrapment models in Baltimore Canyon Basin of Atlantic continental margin geosynclines: Bull. Amer. Assoc. Petrol. Geol., v. 55, pp. 658-679.

Lajoie, Jean, and Chagnon, Andre (1973) Origin of red beds in a Cambrian flysch sequence, Canadian Appalachians, Quebec: Sedimentology, v. 20, pp. 91-103.

Lewis, K. B. (1971) Slumping on a continental slope inclined at 1°-4°: Sedimentology, v. 16, pp. 97-110.

Lowe, D. R. (1972) Implications of three submarine mass-movement deposits, Cretaceous, Sacramento Valley, California: Jour. Sed. Petrology, v. 42, pp. 89-101.

O'Brien, J. M. (1972) Narizian-Refugian (Eocene-Oligocene) marine and marginal marine sedimentation, western Santa Ynez Mountains, Santa Barbara County, California: Amer. Assoc. Petrol. Geol. - Soc. Econ. Pal Min., Pacific Section, Guidebook, Spring Field Trip, pp. 37-43.

Pequegnat, W. E., and others. (1972) Deep-sea ironstone deposits in the Gulf of Mexico: Jour. Sed. Petrology, v. 42, pp. 700-710.

Pett, J. W., and Walker, R. G. (1971) Relationship of flute cast morphology to internal sedimentary structures in turbidites: Jour. Sed. Petrology, v. 41, pp. 114-128.

Piper, J. W., and Normark, W. R. (1971) Re-examination of a Miocene deep-sea fan and fan-valley, southern California: Bull. Geol. Soc. Amer., v. 82, pp. 1823-1830.

Rich, Mark (1971) Middle Pennsylvanian rocks of eastern Great Basin: Bull. Amer. Assoc. Petrol. Geol., v. 55, pp. 432-453.

Ross, D. A. (1971) Sediments of the northern Middle America Trench: Bull. Geol. Soc. Amer., v. 82, pp. 303-322.

Scholle, P. A. (1971) Sedimentology of fine-grained deep-water carbonate turbidites, Monte Antola Flysch (Upper Cretaceous), Northern Appenines, Italy: Bull. Geol Soc. Amer., v. 82, pp. 629-658.

Shepard, F. P., and Emery, K. O. (1973) Congo submarine canyon and fan valley: Bull. Amer. Assoc. Petrol. Geol., v. 57, pp. 1679-1691.

Silver, E. A. (1972) Pleistocene tectonic accretion of the continental slope off Washington: Marine Geology, v. 13, pp. 239-249.

Stanley, D. J., and others. (1971) Lower continental rise east of the Middle Atlantic states: predominant sediment dispersal perpendicular to isobaths: Bull. Geol. Soc. Amer., v. 82, pp. 1831-1840.

Stanley, D. J., and Unrug, Rafael (1972) Submarine channel deposits, fluxoturbidites and other indicators of slope and base-of-slope environments in modern and ancient marine basins: pp. 287-340 in Rigby, J. K., and Hamblin, W. K., editors, Recognition of Ancient Sedimentary Environments, Soc. Econ. Pal. Min., Spec. Publ. No. 16.

Summerhayes, C. P., et. al. (1971) Geological structure and development of the continental margin of northwest Africa: Marine Geology, v. 11, pp. 1-25.

Wilhelm, Oscar, and Ewing, Maurice (1972) Geology and history of the Gulf of Mexico: Bull. Geol. Soc. Amer., v. 83, pp. 575-600.

EOLIAN SYSTEMS

Updated References

Bigarella, J. J. (1972) Eolian environments: their characteristics, recognition and importance: pp. 12-62 in Rigby, J. K., and Hamblin, W. K., editors, Recognition of Ancient Sedimentary Environments: Soc. Econ. Pal. Min. Spec. Publ. No. 16.

Goldsmith, Victor (1973) Internal geometry and origin of vegetated coastal sand dunes: Jour. Sed. Petrology, v. 43, pp. 1128-1142.

Jones, B. G. (1972) Deformation structures in siltstone resulting from the migration of an Upper Devonian aeolian dune: Jour. Sed. Petrology, v. 42, pp. 935-940.

McKee, E. D., and Bigarella, J. J. (1972) Deformational structures in Brazilian coastal dunes: Jour. Sed. Petrology, v. 42, pp. 670-681.

Wilson, I. G. (1972) Aeolian bedforms -- their development and origins: Sedimentology, v. 19, pp. 173-210.

LACUSTRINE SYSTEMS

Updated References

Picard, M. D., and High, L. R., Jr. (1972) Criteria for recognizing lacustrine rocks: pp. 108-145 *in* Rigby, J. K., and Hamblin, W. K., editors, Recognition of Ancient Sedimentary Environments, Soc. Econ. Pal. Min. Spec. Publ. No. 16.

Picard, M. D., and High, L. R., Jr. (1972) Paleoenvironmental reconstructions in an area of rapid facies change, Parachute Creek Member of Green River Formation (Eocene), Vinta Basin, Utah: Bull. Geol. Soc. Amer., v. 83, pp. 2689-2708.

Thomas, R. L., and others (1972) Distribution, composition, and characteristics of the surficial sediments of Lake Ontario: Jour. Sed. Petrology, v. 42, pp. 66-84.

ALLUVIAL FAN SYSTEMS

Updated References

Bull, W. B. (1972) Recognition of alluvial-fan deposits in the stratigraphic record: pp. 63-83 in Rigby, J. K., and Hamblin, W. K., editors, Recognition of Ancient Sedimentary Environments, Soc. Econ. Pal. Min. Spec. Publ. No. 16.

Glennie, K. W. (1972) Permian Rotliegendes of northwest Europe interpreted in light of modern desert sedimentation studies: Bull. Amer. Assoc. Petrol. Geol., v. 56, pp. 1048-1071.

Goldbery, R., and Holland, W. N. (1973) Stratigraphy and sedimentation of redbed facies in Narrabeen Group of Sydney Basin, Australia: Bull. Amer. Assoc. Petrol. Geol., v. 57, pp. 1314-1334.

Howard, J. D. (1966) Patterns of sediment dispersal in the Fountain Formation of Colorado: Mountain Geologist, v. 3, pp. 147-153.

Jones, B. G. (1973) Sedimentology of the Upper Devonian to Lower Carboniferous Finke Group, Amadeus and Warburton Basins, central Australia: Jour. Geol. Soc. Australia, v. 20, pp. 273-293.

Neasham, J. W., and Vondra, C. F. (1972) Stratigraphy and petrology of the Lower Eocene Willwood Formation, Bighorn Basin, Wyoming: Bull. Geol. Soc. Amer., v. 83, pp. 2167-2180.

Rackley, R. I. (1972) Environment of Wyoming Tertiary uranium deposits: Bull. Amer. Assoc. Petrol. Geol., v. 56, pp. 755-774.

Schluger, P. R. (1973) Stratigraphy and sedimentary environments of the Devonian Perry Formation, New Brunswick, Canada, and Maine, U. S. A.: Bull. Geol. Soc. Amer., v. 84, pp. 2533-2548.

Steidtmann, J. R. (1971) Origin of the Pass Peak Formation and equivalent Early Eocene strata, central western Wyoming: Bull. Geol. Soc. Amer., v. 82, pp. 156-176.

FAN DELTA SYSTEMS

Updated References

Deegan, C. E. (1973) Tectonic control of sedimentation at the margin of a Carboniferous depositional basin in Kirkcudbrightshire: Scottish Jour. Geology, v. 9, pp. 1-28.

DeVoto, R. H. (1972) Pennsylvanian and Permian stratigraphy and tectonism in central Colorado: pp. 139-185 *in* R. H. DeVoto, editor, Paleozoic Stratigraphy and Structural Evolution of Colorado: Colo. Sch. Mines Quart., v. 67, No. 4.

Gradstein, F. M., and Van Gelder, A. (1971) Prograding clastic fans and transition from a fluviatile to a marine environment in Neogene deposits of eastern Crete: Geol. en Mijnbouw, v. 50, pp. 383-392.

Kennedy, M. P., and Moore, G. W. (1971) Stratigraphic relations of Upper Cretaceous and Eocene formations, San Diego coastal area, California: Bull. Amer. Assoc. Petrol. Geol., v. 55, pp. 709-722.

MacCarthy, I. A. J., and others (1971) The Garryvoe Conglomerate Formation (Tournaisian) of southern Ireland: Bull. Geol. Survey Ireland, v. 1, No. 2, pp. 119-150.

Stanley, K. O. (1971) Tectonic and sedimentologic history of Lower Jurassic Sunrise and Dunlap Formations, west-central Nevada: Bull. Amer. Assoc. Petrol. Geol., v. 55, pp. 454-477.

Woodward, G. D. (1974) Redefinition of Cenozoic stratigraphic column in Split Mountain Gorge, Imperial Valley, California: Bull. Amer. Assoc. Petrol. Geol., v. 58, pp. 521-539.

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